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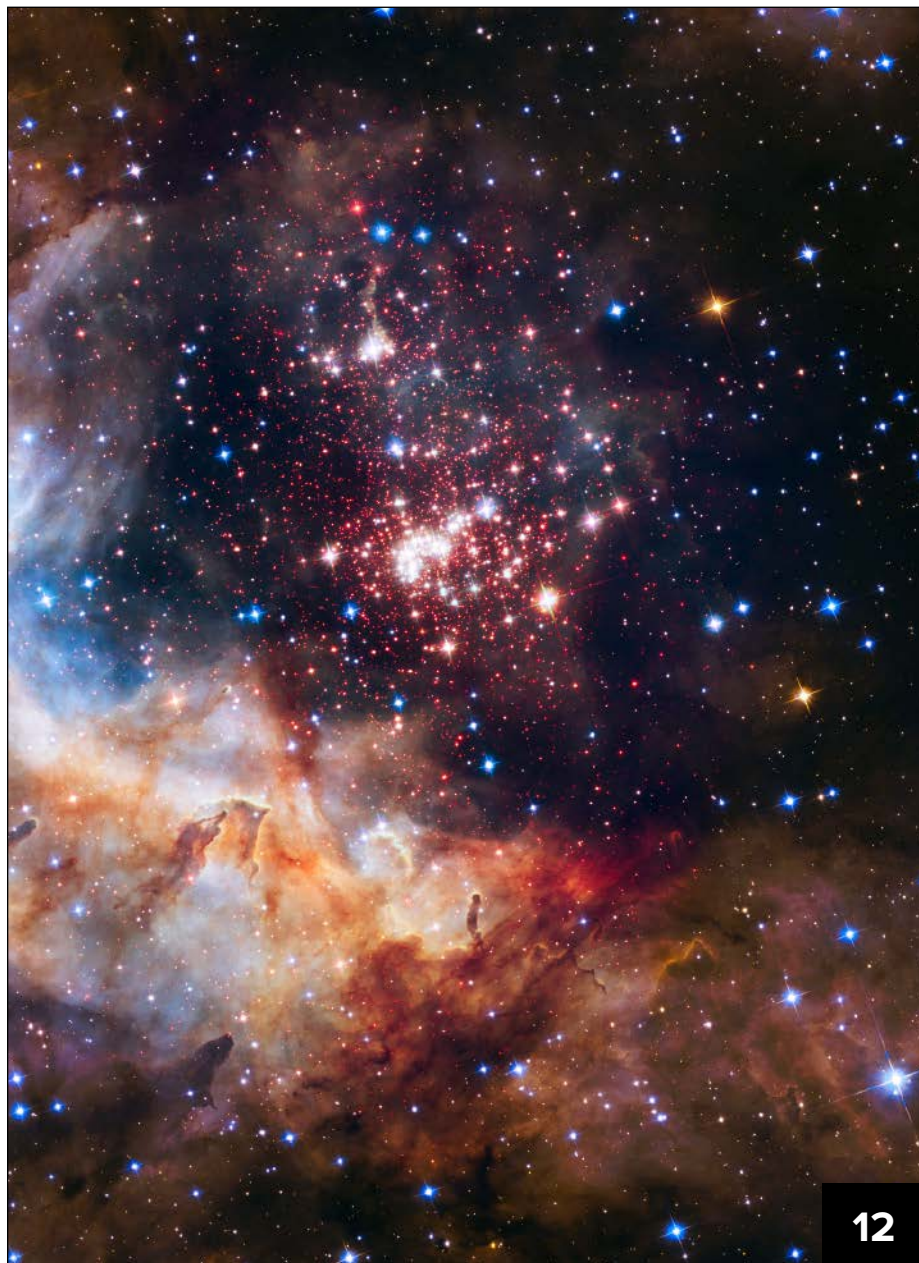


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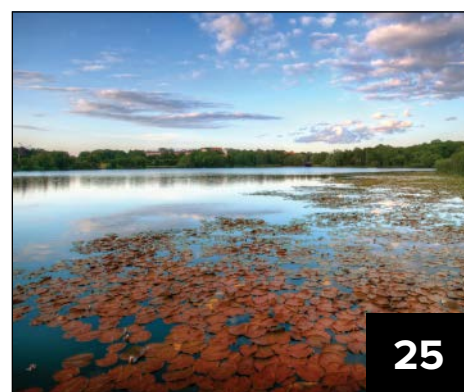
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Office.

Eos (ISSN 0096-3941) is published semi-monthly, on the 1st and 15th of the month
except the 1st of January 2015 by the American Geophysical Union, 2000 Florida
Ave., NW, Washington, DC 20009, USA. Periodical Class postage paid at Washington,
D. C., and at additional mailing offices. POSTMASTER: Send address changes to
Member Service Center, 2000 Florida Ave., NW, Washington, DC 20009, USA.

Member Service Center: 8:00 a.m.–6:00 p.m. Eastern time; Tel: +1-202-462-6900;
Fax: +1-202-328-0566; Tel. orders in U.S.: 1-800-966-2481; Email: service@agu.org.

Use AGU's Geophysical Electronic Manuscript Submissions system to submit a
manuscript: <http://eos-submit.agu.org>.

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U.S. Goals for Arctic Council Include Focus on Climate Change



Government of Canada

U.S. Secretary of State John Kerry (right) speaks with Adm. Robert Papp Jr. (retired), U.S. special representative for the Arctic.

The United States assumed the rotating 2-year chairmanship of the Arctic Council on 24 April with a pledge to address climate change.

U.S. Secretary of State John Kerry vowed that during its chairmanship, the United States “will work every single day with members of this council to help prepare Arctic communities for the impacts of [climate] change, and we’ll do everything we can to prevent even worse impacts in years to come.” He spoke at the council’s meeting in Nunavut Iqaluit, Canada, as the United States assumed the chairmanship of the organization.

Climate change in the Arctic “is not a future challenge. This is happening right now,” Kerry said. Temperatures in the Arctic “are increasing at more than twice the rate of the global average. What these rising temperatures mean is that the resilience of our communities and our ecosystems, the ability of future generations to be able to adapt and live and prosper in the Arctic the way people have for thousands of years, is tragically but actually in jeopardy.”

Focus on Climate Change and Other Key Issues

The U.S. chairmanship will focus on addressing climate change and its impacts; promoting ocean safety, security, and stewardship; and improving economic and living conditions for Arctic communities, Kerry said. The United

States, he stated, also will build on progress made on environmental, economic, and other regional issues during the just-concluded Canadian chairmanship. The council, which is an intergovernmental forum to address Arctic regional issues, has eight member states, includes six indigenous organizations as permanent participants, and has more than 30 observer parties.

Officials at the meeting approved the council’s “Iqaluit

Declaration 2015,” which acknowledges that reducing greenhouse gas emissions “continues to be the most important contribution to addressing global and Arctic climate change and to the long-term conservation and sustainability of the unique Arctic environment.”

Action on Black Carbon and Methane

The declaration implements a Framework for Action on Enhanced Black Carbon and Methane Emissions Reductions in the Arctic (see <http://bit.ly/ACFramework>). It also encourages the creation of an enhanced elevation map of the Arctic “to provide improved information for use in scientific analysis and sustainable development.” In addition, the declaration calls for more awareness about ocean acidification, approves a strategic plan that provides a framework to protect ecosystems and promote sustainable development, and encourages efforts to sustain Arctic communities and build a stronger Arctic Council.

Kerry expressed U.S. support for these and other measures, stating that the United States “intends to press for the full implementation of the framework on black carbon and methane.” He also urged all Arctic Council members and observer nations to join the Global Ocean Acidification Observer Network, an international effort to better understand acidification. “The cold temperatures of the Arctic Ocean make it particularly vulnerable to acidification,

science tells us,” Kerry said. “Despite all of this, incomprehensibly, ocean acidification is often an overlooked impact of climate change.”

Sustainable Development in a Fragile Region

Kerry applauded the council’s efforts on enhancing preparedness for oil spills and similar potential disasters, as well as its work to develop a pan-Arctic network of marine protected areas. He also expressed support for the Arctic Economic Council and efforts to help native communities.

“We’re very well aware that the retreat of sea ice in the region brings with it a lot of opportunities, though not everybody sees them in the same context as opportunities. Shipping lanes are already beginning to open, providing jobs and new possibilities for commercial enterprise,” he said. “It is imperative that the development that we pursue is sensitive to the lifestyle and the history that people want to hold onto.” Kerry added that efforts should ensure that development “is sustainable, that it doesn’t exacerbate other challenges in the Arctic and around the world.”

He continued, “We believe the private sector has a huge role to play in ensuring that we find the right balance, and we have an enormous role to play with the private sector in making sure that they adopt that role and live it out.”

Geopolitical Tensions

During separate press briefings following the meeting, Kerry and Canadian officials responded to questions about Russian military exercises in the Arctic, the hostilities in Ukraine, and whether these concerns could diminish the cooperative nature of the Arctic Council. Kerry said that military issues in the Arctic are legitimate concerns that need to be addressed at some point. However, he stressed that it is better to deal with them through NATO, the United Nations Security Council, or other forums rather than through the Arctic Council.

He said that during a conversation a few days earlier, Russian Foreign Minister Sergey Lavrov “made it crystal clear to me that Russia wants the council to be successful, that they want this to be a cooperative entity that is geared towards peaceful purposes, and that it’s their intent to cooperate with us on the protection of the environment on the agenda that we have set forth.”

Nonetheless, tensions remain high. Canadian Foreign Minister Robert Nicholson remarked, “We condemn the Russian aggression against Ukraine.”

By **Randy Showstack**, Staff Writer

Finding Debris Clouds Around Asteroids Headed Our Way



An artist's rendition of a fragmented asteroid.

Small spikes in the magnetic field in our solar system may reveal dust and debris, including some on a collision path with Earth, according to a researcher at the European Geosciences Union (EGU) General Assembly in Vienna, Austria.

The solar wind, which consists of charged particles flowing at high speed from the Sun, creates a magnetic field detectable from interplanetary space probes. Planetary scientist Christopher Russell of the University of California, Los Angeles and his colleagues have been examining small wrinkles in that magnetic field called interplanetary field enhancements (IFE) since the 1980s. At an EGU session on 13 April, Russell presented the latest evidence that it might be possible to use IFEs to detect asteroid-orbiting clouds of dust and rock, including some that threaten Earth.

Objects smaller than that are probably much more common than earlier estimates, according to a slew of new studies last year.

"The dust is sort of a warning signal. It's the smoke telling you where the fire is," he told *Eos*.

A Focus on Near-Earth Objects

The explosion of a meteor in the sky near the city of Chelyabinsk, Russia, in 2013 focused attention on the need for such signals. The event shook buildings, broke windows, and caused minor injuries, including cuts and sunburns, according to a report in *Science* (see <http://bit.ly/MeteoriteRussia>).

In response, the U.S. Congress doubled NASA's near-Earth object (NEO) search budget to roughly \$40 million a year. In addition, the private B612 Foundation in Menlo Park, Calif., is also planning its own mission, dubbed Sentinel, to detect more NEOs. The Sentinel team is promoting 30 June 2015 as

Asteroid Day, *Eos* reported late last year (see <http://bit.ly/EosAsteroid>).

NASA claims that it has detected and is tracking the majority of NEOs larger than 1 kilometer in diameter. In addition, it aims to detect 90% of objects down to 140 meters. Objects smaller than that are probably much more common than earlier estimates, according to a slew of new studies last year (see <http://bit.ly/NEOSTudies>). The studies indicate that these small NEOs can still cause major damage.

Seeing into the Shadows

Today's detection efforts rely on radar and optical telescopes. However, optical methods depend on light reflected from very dark objects, and for radar and optical instruments the smaller targets are more difficult to detect.

Russell pointed out during his talk that known NEOs may be co-orbited by debris large enough to cause damage on Earth even if the host objects miss Earth. For example, one estimate put the Chelyabinsk meteor at only 17 meters in diameter. An object that size could be difficult to detect via conventional methods if it is hiding in the shadow of a much larger asteroid.

However, because such objects are likely the result of recent collisions, Russell says they are likely to be accompanied by smaller debris and fine dust. This dust may be the key to identifying these small objects co-orbiting with NEOs.

A New Method

Russell argued during his presentation that nanoscale particles from such collisions pick up charges and interact in a detectable way with the solar wind. Earlier this year his team published a paper in *Geophysical Research Letters* that used magnetometer data from five spacecraft to document momentum transfer from the solar wind to a dust cloud (see <http://bit.ly/GRLHRLai>). The multiple perspectives from all those spacecraft made it possible to triangulate the location of the IFEs and put some boundaries on their three-dimensional structure.

At the EGU meeting, Russell reported that the team has associated two specific IFEs with two different objects: asteroid 2201 Oljato and the potentially hazardous asteroid 138175. Asteroid 2201 Oljato does not threaten Earth yet, but asteroid 138175 is on NASA's watch list.

"We want to quantify the size of the cloud of dust," Russell says. Getting a handle on the dust cloud size will help researchers predict the mass and distribution of matter within and surrounding NEOs. That could help guide targeted observations with higher-resolution optical telescopes to determine whether the

dust cloud is hosting any potentially hazardous co-orbiting objects, Russell explained.

If the researchers can establish the relationship between the strength of magnetic disturbances and dust cloud size, the magnetometer data already pouring back from many interplanetary missions could be a rich source of information for fine-tuning Earth's planetary defense.

More Perspectives on IFEs' Link to Asteroids

Geraint H. Jones of Imperial College London in the United Kingdom has also examined IFEs in data from the Ulysses spacecraft. In 2003, he and colleagues reported in *Icarus* that IFEs trailed comets, not asteroids (see <http://bit.ly/IcarusJones>). The charges that modified the solar wind's magnetic field probably came from ions the comet emitted, Jones says.

If IFEs only trail comets—which are larger, easier to detect, and cross Earth's path less frequently than asteroids—they may be less useful for planetary defense. However, in the case that Russell and colleagues reported, “charged dust essentially behaves like a very, very heavy ion,” Jones told *Eos*.

Jones said Russell's study with “the multiple points of view from five spacecraft: that's made a big difference. It does appear that dust has an effect on the solar wind and it's, I think, larger than people would have expected otherwise.” That said, he says he would next like to see a model of the physics of asteroid impacts, dust clouds, and IFEs that predicts the observations.

Russell says he wants to obtain multiple detections of an IFE associated with an asteroid to conclude that the signal is coming from dust activity and to repeat the observation for multiple objects. He says the team is now selecting likely targets for observation on the basis of their paths and orbital periods. Then they will conduct simulations of how such debris clouds form around NEOs in the first place.

The method is also limited by the fact that detecting IFEs is possible only when the object passes between the Sun and a space-based magnetometer. Because most asteroids orbit beyond Mars, surveying them would require very far-flung spacecraft.

However, if Russell's team can make a convincing link between IFEs and the halos of debris around NEOs, the next logical step, Russell says, is “just going down the list of asteroids” to see which known NEOs have potentially dangerous orbiting debris clouds.

Science Journalists Face Government Roadblocks, Survey Finds

Science, environment, and health journalists struggle to get information from governmental agencies for their stories and often need to go through public information offices to reach experts. That is a key finding from a 9 April report issued by the Society of Professional Journalists (SPJ) and the Union of Concerned Scientists.

The report, based on a new survey, found that science agencies “may be more open and less controlling than other types of government agencies surveyed in earlier studies.” However, a result from the new survey “shows that there are still extensive restraints on experts and journalists communicating with each other,” the report states.

A majority of science journalists surveyed, 56.8%, agreed with the statement that “the public is not getting all the information it needs because of barriers agencies are imposing on journalists' reporting practices.” That figure is less than that in earlier SPJ surveys, in which 85% of journalists who report on federal agencies and 76.1% of education reporters agreed with that statement.

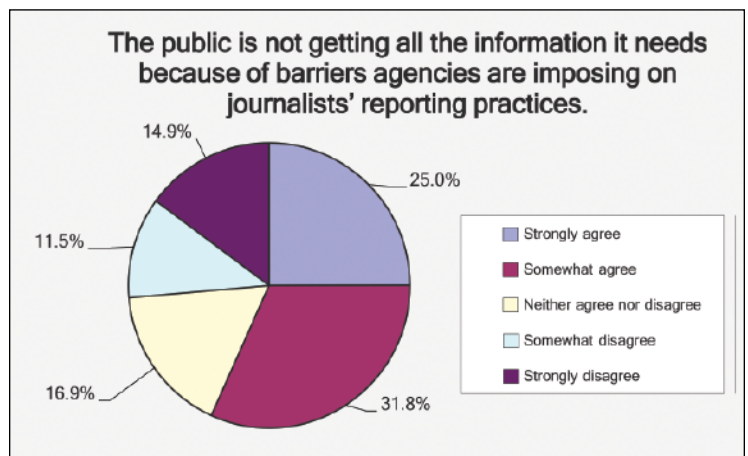
Media Access to Earth Science Agencies

At a briefing in Washington, D. C., to release the report, panelists acknowledged that some agencies involved with the Earth and space sciences have generally good media policies. The agencies they specifically cited include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and NASA. However, panelists said there is room for improvement at some other agencies, including the U.S. Environmental Protection Agency (EPA).

According to the report, *Mediated Access: Science Writers' Perceptions of Public Information Officers' Media Control Efforts*, “the hazard of suppression of information and ideas is

multifold. It includes muddling of understanding needed to solve problems, even among scientists themselves; manipulation of the public for various motivations; and the indefinite veiling of problems and malfeasance. Both the science and the journalism communities may want to consider issues the current situation presents in light of these findings” (see <http://bit.ly/SPJUCSSurvey>).

Other findings are that 46.1% of science journalists reported that they had been pre-



Responses to one of the questions asked in a recent survey of science writers.

vented from interviewing agency employees in a timely manner at least some of the time, which was higher than education journalists (32.6%) but lower than federal agency reporters (69%). Science journalists reported being more successful (32.2%) at getting interviews without involving an agency's public information office (PIO) than other groups surveyed earlier, including education reporters at 21.3% and federal agency reporters at 15%. Also, 63.8% of science journalists reported having a positive working relationship with PIOs.

The survey, conducted by SPJ in January and February, elicited 254 responses from journalists covering science, environment, health, and medicine. The margin of error is $\pm 5.7\%$. The report draws some conclusions from the findings, but it does not make recommendations, said report author Carolyn Carlson, a member of the SPJ Freedom of Information Committee. The committee is a watchdog of press freedoms across the United States.

Concern About Hampering the Information Flow

At the briefing, SPJ released a statement saying the new survey shows that “the restrictions specifically hamper the flow of scientific information to the public—which means they also hamper the movement of information to the rest of the community. The organization asked U.S. president Barack Obama “to end restrictions on reporters communicating with staff about the public’s business.”

Kathryn Foxhall, a member of the SPJ Freedom of Information Committee, said, “Over about 20 years, there has been a surge in agencies and other entities requiring reporters to always go through PIOs before speaking to employees. On an historical basis, the constraints are new and they are radical.” She added that “when reporters are required to go through PIOs to talk to anyone, the source people know they [are] under surveillance by the official structure and that changes everything.”

In an interview with *Eos*, Foxhall said that she and others were disappointed in the White House Office of Science and Technology Policy’s guidance to federal executive departments and agencies on public communications that is included in a 17 December 2010 memorandum on scientific integrity (see <http://bit.ly/OSTPmemo>). That memo states, in part, that “federal scientists may

speak to the media and the public about scientific and technological matters based on their official work, with appropriate coordination with their immediate supervisor and their public affairs office.”

Foxhall told *Eos* that the language “was exactly the opposite of what we had been working for, and what we had told the administration

needed to be done. To my knowledge, it was the first time in his history that this policy of people being forbidden to

“It is accepted around Washington that a reporter cannot speak to anyone in an agency without going through the public affairs office.”

speak to each other, except when they were under surveillance, had actually been put in written policy, by an administration.”

“The administration has entrenched this culture, these constraints that have been growing up over about three administrations,” she added. “And now, it is accepted around Washington that a reporter cannot speak to anyone in an agency without going through the public affairs office. That is message control.”

Transparency Efforts and the Obama Administration

Michael Halpern, program manager of the Union of Concerned Scientists’ Center for Science and Democracy, said that since President Obama took office, the administration has “talked about wanting to put a premium on transparency, with mixed results.”

Halpern said that although the administration has put a lot of effort into access to data, “there has been a lot less attention

on those who can put meaning to that data and interpret it and put it in the proper context.”

He said that some agencies, including NOAA and USGS, have relatively open policies in working with the media and are setting the standards that other agencies should be able to follow. “Halpern noted that media access has been “a sticking point” with EPA. He said that although the agency has made strides in other areas, “access to scientists is not one of those areas where there has been a lot of progress.”

“Scientists should be able to speak to the public and the press without having to ask for permission,” Halpern stated. He noted that scientists should be clear about when they are speaking as an agency representative and when they are speaking as an individual, to avoid confusion.

“The assumption should be openness unless there is a compelling reason” for not doing so, Halpern said. Further, he said that agencies should be looking at successful examples within government for best practices to replicate, so that as much information as possible can emerge “without compromising things like the scientific process or proprietary information or other things that rightly should be more private and more deliberative.”

Panelist Kate Sheppard, senior reporter and environment and energy editor at the *Huffington Post*, added, “Journalism benefits when reporters have access to experts, and society benefits because they have a better understanding of the issues when reporters have access to experts and not just the PIO.”

By **Randy Showstack**, Staff Writer

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Correction

In the 1 May 2015 issue, a formatting error in the feature “Why Does the Aurora Flare Up?” by Syun-Ichi Akasofu caused numbers that should have been represented in scientific notation not to have superscripts.

The affected sentences on pages 18–19 should read as follows:

“When the power becomes strong enough (at about 10^{11} watts, roughly equivalent to the total power of the thousand largest power plants in the world), the Earth’s magnetosphere responds.”

“The total heat production is estimated to be up to 10^{16} joules, which is dissipated at a rate of about 5×10^{11} watts during the expansion phase.”

“What is unclear—and very controversial—is where the magnetosphere can stably store as much as 10^{16} joules.”

“In fact, it is likely that the main body may not even be able to store more than 10^{16} joules; the magnetosphere may become unstable before the stored energy reaches this threshold.”

Eos regrets these errors.

Renewable Energy Trend Could Help with Climate Mitigation



Solar thermal collectors in the California desert.

A largely positive new report on renewable energy trends could provide a shot in the arm for the upcoming climate negotiations set for Paris, France, at the end of the year.

The global investment in renewable power and fuels increased 17% in 2014 to \$270 billion, according to the United Nations Environment Programme's (UNEP) 31 March report, *Global Trends in Renewable Energy Investment 2015* (see <http://bit.ly/UNEPRenewables>). UNEP notes that this figure does not include large-scale hydropower projects exceeding 50 megawatts because that technology has been mature for decades.

The level of investment was higher than in any year except for the record \$278.8 billion in 2011 and represents the first increase in investment in 3 years. The high level in 2014 is largely due to a \$74.9 billion boom in solar installations in China and Japan and a record \$18.6 billion in final investment decisions for European offshore wind projects, according to the report, which was prepared by the Frankfurt School–UNEP Collaborating Center and Bloomberg New Energy Finance.

Effects of 2014's Renewable Energy Trends on Climate

Findings include the fact that a record-breaking 95 gigawatts of wind and solar photovoltaic power systems were installed in 2014 compared with 74 gigawatts in 2013. In addition, renewable energy technologies made up 48% of net power capacity added worldwide in 2014, and the proportion of electricity generated from cumulative installed renewable power capacity increased to 9.1% in 2014 compared with 8.5% in 2013.

These trends “prevented the emission of an estimated 1.3 gigatonnes” of carbon dioxide, the report states. “However, at the recent rate of increase, it will take until 2030 for renewables excluding large hydro to reach 20% of global generation,” according to the report.

The Impact of Lower Oil Prices

The recent plunge in the price of crude oil will “dampen investor confidence” in parts of the renewable energy sector, including in developing countries that burn oil for power and in the biofuel market, according to the report. However, oil and renewables “do not compete

for power sector dollars” in most of the world.

“Wind and solar sectors should be able to carry on flourishing, particularly if they continue to cut costs” per megawatt hour, the report adds.

Outlook on Renewables

United Nations secretary-general Ban Ki-moon wrote in the foreword that the report “increases our confidence that a low-carbon world is obtainable and that we are on the right path to reach our objective, even though there is still much to accomplish.” Ban cautioned that “policy uncertainty and other barriers to investment need to be abolished.”

He said that a further mobilization of financial markets to support low-carbon growth could come out of the Paris climate summit. “We need more private and public investment incentives—including putting a price on carbon to provide markets with the right policy signals to move them to invest in climate solutions.”

At a 1 April speech in Washington, D. C., UNEP executive director Achim Steiner said the increase in renewable energy “is the most significant shift of any source of energy ever in the history of modern energy systems.”

The levels of investment show that renewables are “not some niche market that is coming to maturity,” he added. Rather, the world is seeing “technology coinciding with a public policy challenge and an economic transformation challenge unprecedented in modern industrialized development.”

Steiner said that although the 2014 investment numbers did not set a record, the decline in prices in renewable technology “buys you a lot more in installed capacity than in 2011.”

More Work Needed to Limit Greenhouse Emissions

At a 31 March briefing in Geneva, Switzerland, to release the report, several speakers cautioned that although the report has much good news regarding renewables, a lot of work is required to limit greenhouse gas emissions and to speed the shift to renewables.

“We do seem to be in a slightly more optimistic mood at the moment,” said Angus McCrone, chief editor of Bloomberg New Energy Finance and a lead author of the report. He said, however, “One should not underestimate the challenges there.”

Specifically, “there really is a lot to do to get a credible signal to the investor that a really high fraction of renewables has a long-term place in the electricity mix,” McCrone explained.

By **Randy Showstack**, Staff Writer

Climate and Ocean Dynamics During the Cretaceous

Exploring the Cretaceous World with Data and Numerical Models

Capo Granitola, 2–4 October 2014

Significant efforts have been undertaken to improve scientists' understanding of the time scales and processes affecting the climate and ocean dynamics roughly 66–145 million years ago during the Cretaceous. Often described as Earth's "greenhouse" time, the Cretaceous featured plate configurations, ocean circulation, carbon dioxide concentrations, sea surface temperatures, and salinity that differed considerably from modern-day conditions.

Widespread deposition of organic carbon-rich sediments during oceanic anoxic events (OAEs; times of total depletion of dissolved oceanic oxygen) reflects peculiar oceanography and biogeochemistry. These OAEs were marked by large equatorial upwelling zones in the Pacific, Atlantic, and Tethys oceans, coupled with widespread anoxia in the Atlantic and western Tethys oceans.

Paleoceanographic and paleoclimatic topics of the Cretaceous were the focus of a work-

shop last October in Sicily, Italy. Participants included 28 scientists of different nationalities with expertise in astronomy, paleontology, sedimentary geology, stratigraphy, geochronology, geochemistry, and climate and ocean modeling.

Seven keynote lectures given by experts in the different fields provided insight into the state-of-the-art research into the entire Cretaceous Earth system, with particular focus on

- climate dynamics and evolution of marine and terrestrial biota at times of changing climate
- exploration of new tools providing more reliable calibration of the Cretaceous sedimentary records, including astrochronology
- analysis of climate and ocean dynamics during the Cretaceous OAEs

Speakers summarized developments in recording Cretaceous stratigraphy and assessed and discussed gaps in the knowledge of the fine details of the geological time scale within the Cretaceous, which are mainly due

to the limited availability of radiometric dated records, precise integrated stratigraphy, and reliable and accurate orbital tuning of sedimentary sequences.

Working group sessions formed the core of the workshop. One working group provided a road map for future investigation in stratigraphy and the development of accurate and reliable age models based on astrochronology combined with other stratigraphic methods. Another working group focused on aspects of physical, chemical, and biological oceanography at times when Earth's orbital configuration changed during Cretaceous greenhouse and icehouse intervals.

A third working group identified future research themes in the field of paleoceanography at times of OAEs, which are seen as the global oceanic expression of major carbon cycle perturbations. This group also discussed questions concerning possible links between the carbon cycle and changes in carbon dioxide concentrations, as well as

related temperature trends. A fourth working group discussed future needs regarding the modeling of physical and biogeochemical parameters using improved empirical data.

For more details on specific sessions and working groups, visit http://bit.ly/Eos_Cretaceous.

Acknowledgments

The workshop was supported by the European Science Foundation's Research Networking Program, under the umbrella of the European Union's Earthtime program. We thank E. Erba, S. Flögel, and H. Weissert for their crucial contributions to this report and all the workshop participants for their constructive and enthusiastic input.

By **Mario Sprovieri**, Institute for Coastal Marine Environment, National Research Council, Capo Granitola, Italy; email: mario.sprovieri@cnr.it



A remnant of submarine sediments from the eastern Tethys Ocean preserved in the Al Hajar Mountains in Oman features chert underlying the basin (foreground) and carbonates from an adjacent plateau (background).

Advancing Multinational Research in the Highest Mountain Regions

5th Third Pole Environment Workshop

Berlin, Germany, 8–9 December 2014

The vast region encompassing Earth's highest mountain ranges, part of the great Asian mountain system, goes by many names. One is the "Roof of the World." Another is "Asia's Water Tower" because of the region's characteristic high altitudes, positioned directly upriver from the world's most densely populated countries.

Scientists racing to study its extensive, yet changing, glacial mass have dubbed the region the "Third Pole." Largely because of the inhospitable physical landscape and geopolitical barriers, this trans-boundary mountain region posed a significant challenge to cooperative, multinational research. As a result, the area has remained relatively understudied within the realms of Earth and environmental science, despite its importance in the livelihood of billions of people.

To advance research and increase coordinated field campaigns in the region, scientists and stakeholders representing 13 countries gathered in December 2014 in Berlin, Germany, to discuss progress and future plans for the Third Pole Environment (TPE) program.

Participants shared their unique and diverse portfolios of environmental research on topics including climate and

cryosphere dynamics, geologic processes, geohazards, land-atmosphere interactions, lakes and rivers, and biologic and biodiversity studies.

Research highlights included the study of black carbon in snow by Baiqing Xu (Institute of Tibetan Plateau Research, Chinese Academy of Sciences (ITPCAS)) and the extensive remote sensing efforts to document glacier changes in the Third Pole region by Tobias Bolch (University of Zurich/Dresden University of Technology).

Research highlights included the study of black carbon in snow and the extensive remote sensing efforts to document glacier changes in the Third Pole region.

Given the complexities of the region, the opportunity for multidisciplinary, multinational information sharing and discussion is an invaluable component of the TPE program's research. Common threads in the presentations were the Asian monsoon system, improving the accuracy and spatial coverage of environmental reconstructions, advancing data availability, and data-sharing platforms.

Participants eagerly discussed ways to increase coordinated field campaigns, with a focus on transboundary research transects, an ongoing effort that may provide a more complete picture of the Third Pole.

Participants also emphasized how the lack of long-term data and sparse coverage in the expansive geographic area that encompasses the Third Pole have led to increased uncertainty and disagreement about past environmental events and regional future projections. Throughout the meeting, the importance of

the TPE program as a platform for heightened, coordinated research efforts was stressed.

Although the TPE program has supported more than a dozen field campaigns in the past 2 years, undertaking expeditions in China, Nepal, Pakistan, and Tajikistan, participants concluded that there is an urgent need for additional research focus and funding and expanded aerial coverage of both field data and remotely sensed data. Attendees agreed that the TPE program's newly established international research center in Kathmandu, Nepal, should serve not only as a local office and student training center but also as a base to support scientific field activities on the southern slope of the Himalayas.

The TPE program is cochaired by Lonnie Thompson (Ohio State University), Tandong Yao (ITPCAS), and Volker Mosbrugger (Senckenberg Research Center for Nature Study, Germany). More information about the TPE program can be found at <http://www.tpe.ac.cn/>.

By **Daniel Joswiak**, **Meri Joswiak**, and **Tandong Yao**, Institute of Tibetan Plateau Research, Chinese Academy of Sciences (ITPCAS), Beijing, China; email: daniel@itpcas.ac.cn



The Tibetan Plateau, source of the Mekong, Yangtze, Indus, Brahmaputra, and other major Asian rivers.

rethinkjan, CC-BY 2.0 (<http://bit.ly/ccby2-0>)

Is the Shale Boom Reversing Progress in Curbing Ozone Pollution?



Gas flaring from an oil well in the Eagle Ford Shale field in southern Texas.

As highlighted in an *Eos* opinion piece last year [Alley *et al.*, 2014], environmental impacts of the U.S. oil and gas boom are “hotly debated.” However, a lack of environmental data concerning the largely unregulated but rapidly developing shale industry hampers clarity in this debate. As a result, scientists, public officials, and the public regularly describe effects, such as those on public health, with only anecdotal evidence.

One such shale region is the Eagle Ford Shale (Figure 1). As one of the most productive shale oil and gas regions in the United States, the Eagle Ford has transformed the economies of the mostly rural communities it underlies since 2008.

However, fugitive hydrocarbon emissions from various sources during drilling, completion, and production, as well as gas flares lit to dispose of so-called associated gas—gas that comes out of solution when produced oil depressurizes—affect the air quality of the communities in the region. In particular, the rise in volatile organic compounds (VOCs)—precursors to ground-level ozone formation—worry some local governments. Over the past several decades, the United States has made significant strides in reducing summer smog produced primarily from car exhaust [Parrish *et al.*, 2011]. Unfortunately, new observations lead us to suspect that the shale boom may be threatening that progress.

Flares in the Eagle Ford

In the Eagle Ford, annual drilling permit counts have increased dramatically since the development of the shale, with 26 permits issued in 2008 versus 4416 permits issued in 2013 [Railroad Commission of Texas, 2014]. With 17,685 wells permitted or completed as of 4 December 2014 [Railroad Commission of Texas, 2014], drilling has outpaced the growth of the pipeline network in this part of Texas, resulting in large amounts of near-permanent flaring of associated gas at oil wells, as well as temporary flaring at new gas wells.

Flaring replaces venting and is intended to reduce the direct emissions of methane and other associated gas. Controlled flaring, where flares act to dispose of chemicals safely, is typically more than 98% effective and operates only for limited periods of time. However, flaring at individual oil and gas extraction wells is rarely controlled

and may therefore become a significant source of air pollutants, particularly soot and VOCs, adding to any fugitive emissions of hydrocarbons during drilling, well operation, and oil and gas distribution [Brandt *et al.*, 2014].

Aerial views of the Eagle Ford at night allow for easy detection of flares. These views show that the number of flares has increased rapidly in recent years, largely because of a recent shift from shale gas to shale oil extraction for economic reasons.

Unregulated Emissions

Because governments do not always regulate flaring effectively and because until recently emissions per flare were presumed small, according to the U.S. Environmental Protection Agency (EPA), few scientific efforts have gone into related air quality assessments in shale exploration areas [e.g., Thompson *et al.*, 2014]. Several recent studies, however, show that EPA surveys likely underestimate methane emissions from oil and gas extraction activities [Howarth, 2014], and fewer studies have placed an emphasis on flaring or coemitted hydrocarbon emissions as sources of air pollution.

Although unburned fugitive hydrocarbon emissions are expected to contribute little, VOCs formed in flares, specifically unsaturated hydrocarbons and aldehydes such as ethene and formaldehyde, are potent precursors of local and regional ozone formation.

Incomplete Studies

Ozone mixing ratios in the San Antonio metropolitan area, typically downwind of the

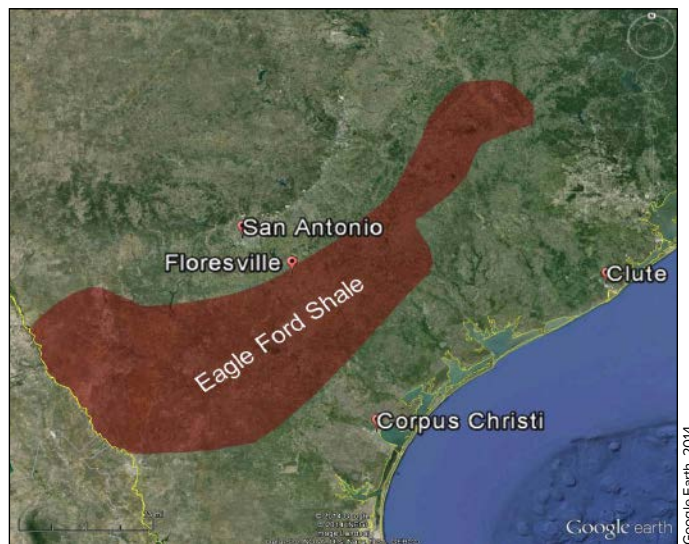


Fig. 1. Outline of the Eagle Ford Shale and selected monitoring locations for volatile organic compounds administered by the Texas Commission on Environmental Quality.

Eagle Ford, have increased in parallel to oil production and associated flaring (Figure 2a). Concerned by the increasing ozone mixing ratios, the Alamo Area Council of Governments (AACOG) developed an emissions inventory and scenario for the shale area and studied the potential effects on regional ozone formation [AACOG Natural Resources/Transportation Department, 2013, 2014].

The findings included VOC emissions likely exceeding metropolitan emissions in San Antonio and significant ozone formation from shale area VOC and nitrogen oxide (NO_x) emissions but possibly no future ozone standard violations.

We question the latter because it is based on conservative and outdated assumptions about flaring emissions. The AACOG study worked with approximately half the NO_x and VOC emissions listed in newer estimates and did not account for less efficient flares and more reactive VOC emissions, such as formaldehyde. Field-based results from Canada using VOC measurements affected by flares [Simpson et al., 2013; Strosher, 2000] strongly suggest that both reactive VOC emissions, such as ethene, and air toxics, such as benzene, are among the emissions.

Toward a Clearer Picture of Air Quality

The Texas Commission on Environmental Quality (TCEQ) monitors VOCs at various locations throughout the state, including the Barnett Shale dry gas production area close to the Dallas/Fort Worth metroplex, where little flaring occurs. To address growing concerns in central Texas, TCEQ installed a new VOC monitor north of the Eagle Ford in summer 2013 and another recently in Karnes City, the heart of the Eagle Ford. There is thus no long-term history on local air quality as affected by oil and gas exploration in the Eagle Ford.

Nonetheless, using TCEQ data, we analyzed VOC monitor data from western San Antonio (Old Highway 90), the Gulf Coast (Corpus Christi and Clute), and the monitor near the Eagle Ford in southeast Floresville. Data at Floresville are collected once per hour using an automated gas chromatograph–flame ionization detection system. VOC data from all other sites are collected over 24 hours once every 6 days; mixing ratios are assessed using gas chromatography–mass spectrometry.

We restricted our analysis to air mass origins in the Gulf of Mexico and focused on the development of ethane as a marker of oil and gas exploration. As shown in Figure 2b, ethane mixing ratios along the coast have remained relatively constant since 2007, but inland mixing ratios have been steadily increasing since 2009.

During the early years of Eagle Ford Shale development (2008 to 2011), ethane mixing ratios in San Antonio were less than 2 parts per billion (ppb) higher than those in Corpus Christi. However, in 2012 and 2013, the enhancement of ethane between Corpus Christi and San Antonio increased to 4–5 ppb on average, a highly statistically significant ($p < 0.0002$) increase.

When the new Floresville monitor data are analyzed as a function of wind direction (example in Figure 2c), two directions stand out: southwest to west and east to southeast, directions for which the approaching air masses spend more time in the shale area and pass over large flaring sources. Ethane mixing ratios from both of these directions are statistically significantly greater than mixing ratios from the south-east to southwest direction ($p < 0.0001$).

Shale Oil and Gas:

A Major Source of Air Pollution

Although we continue to analyze the data, these snapshots clearly show that the boom of unconventional oil and gas exploration is developing into a major source of air pollution in this area. Air quality modeling should provide further confirmation of these preliminary findings.

Nonetheless, we suggest that these rapid changes to air quality have begun to counter the EPA-documented progress made in reducing ozone pollution in the past several decades.

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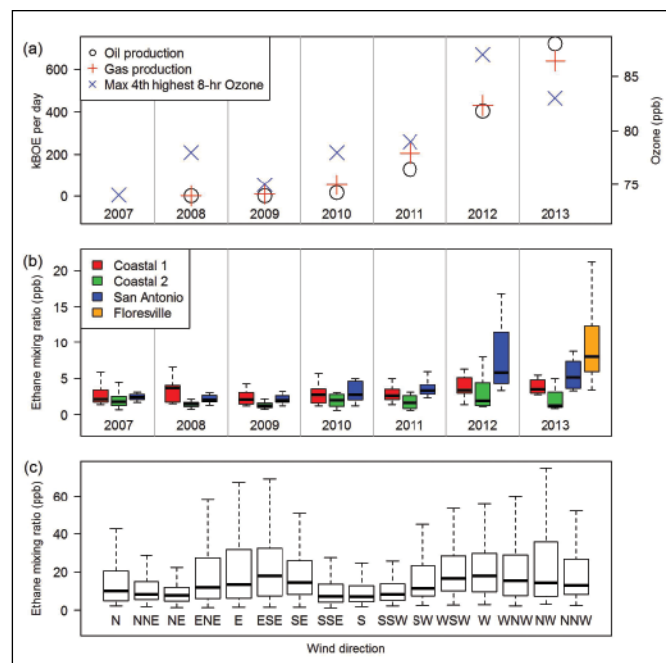


Fig. 2. (a) A comparison of daily crude oil and natural gas production in the Eagle Ford in thousand barrels of oil equivalent (kBOE) per day and maximum observed fourth-highest 8-hour ozone mixing ratios in San Antonio. Note the apparent correlation between oil and gas production rates in the Eagle Ford and ozone mixing ratios in San Antonio. (b) Distribution of ethane mixing ratios in parts per billion (ppb) at various sites in Texas for days with wind trajectories passing near coastal sites, through the Eagle Ford, and ending in San Antonio. Floresville ethane data span a period of approximately 1 year from July 2013 to July 2014. Ethane mixing ratios in San Antonio increase significantly between the early years of the Eagle Ford and recent years; there is no noticeable trend at the coastal sites. (c) Dependence of ethane mixing ratios on wind direction at the Floresville monitor. Ethane mixing ratios are elevated when winds are blowing along the axis of the shale—southwest to west and east to southeast.

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Hubble Turns 25

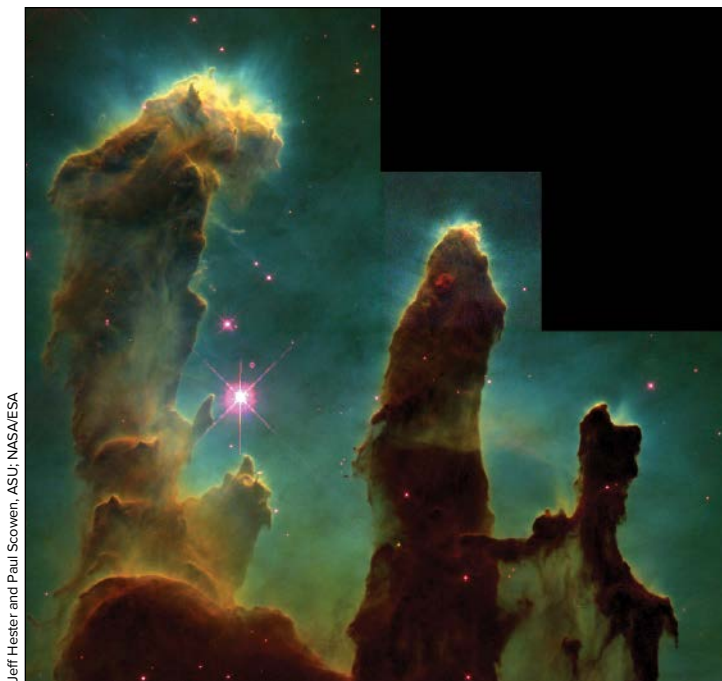
By Ron Cowen

On 24 April 1990, the space shuttle *Discovery* rumbled into space carrying a school bus-sized payload: the largest astronomical telescope ever to fly above the haze of Earth's atmosphere.

Named for Edwin Hubble, the American astronomer who proved that the universe is expanding and that there are galaxies beyond ours, the Hubble Space Telescope has peered deeper into space and with greater clarity than any telescope before it.

Its images have given astronomers the first photo album of galaxies, charting their evolution from surprisingly massive blobs in the infant universe to the majestic spiral and elliptical galaxies of today. Hubble, funded by NASA and the European Space Agency, has pinned down the age of the universe and discovered compelling evidence

NASA



Jeff Hester and Paul Scowen, ASU, NASA/ESA

Iconic image of star birth in the Eagle Nebula, recorded by Hubble in 1995. Newborn stars are emerging from pockets of interstellar gas. The stars lie at the tips of giant columns of gas and dust, which are the cocoons in which the newborns are incubated.

for the existence of supermassive black holes. The telescope's observations of distant exploding stars helped convince astronomers that the universe is being ripped apart, expanding at an ever-faster rate. That accelerated expansion has been called one of the greatest mysteries in all of physics.

Closer to home, Hubble has examined the atmospheres of alien worlds that lie relatively nearby—planets orbiting stars from a few tens to a few hundreds of light-years from the Sun. It has also given new insight into the processes that govern the formation and evolution of our own solar system.

"Hubble is the most important piece of scientific hardware that's ever been built by humans and has returned more scientific information about the physical world than any other device in human history," says astronaut Drew Feustel, who helped repair and upgrade Hubble during the observatory's final servicing mission in 2009.

Hubble is also a story of bouncing back from catastrophic failures, according to Robert Williams, an astronomer and former director of the Space Telescope Science Institute (STScI) in Baltimore, Md., which operates Hubble. First, astronomers had to find a way for the telescope to recover from its notoriously flawed primary mirror, which blurred the vision of the observatory, causing some people to brand the \$1.6 billion telescope a "techno-turkey." A decade later, the telescope got another death sentence: On

the heels of the *Columbia* space shuttle disaster on 1 February 2003, a NASA administrator declared that it was too dangerous to allow another shuttle mission ever to service Hubble.

Failure and redemption, breathtaking images, and a demonstration of humankind's ability to work in space—"all of these factors working together" have made Hubble a cultural icon, says Williams.

Early Days

Hubble's roots go back to 1946—12 years before NASA was founded—when astronomer Lyman Spitzer suggested that scientists build, launch, and operate an observatory in space. Flying above Earth's atmosphere solves a problem that has plagued astronomers since the time of Galileo: As the pristine light from stars and galaxies travels through our planet's atmosphere, it becomes distorted by the layers of turbulent gases, limiting the ability of telescopes on the ground to produce clear images. The atmosphere also blocks or obscures several bands of wavelengths in the electromagnetic spectrum, including those in the ultraviolet, preventing ground-based telescopes from making a full portrait of the cosmos.

Spitzer's idea for a space telescope didn't take off until 1962, when the U.S. National

Academy of Sciences recommended that NASA begin planning for a large orbiting observatory.

The telescope was finally ready for launch by the mid-1980s, but the explosion of the space shuttle *Challenger* during liftoff on 28 January 1986 delayed the telescope's debut. At the time of its launch in 1990, Hubble carried equipment that had been built in the 1970s.

Two months after Hubble entered orbit, NASA discovered that the observatory's 2.4-meter-wide mirror was misshapen, with its outer edge ground too flat by 4 micrometers, about one fiftieth the diameter of a human hair. The tiny flaw was enough to blur the observatory's image: Only the central 20% of each picture was in focus.

Hubble and NASA became objects of ridicule.

By December 1993, when NASA launched a space shuttle mission to fix the telescope, blurry vision was

Hubble is the most important piece of scientific hardware that's ever been built by humans.

only one of Hubble's problems. Failing gyroscopes prevented the observatory from staying fixed on celestial targets. In addition, the transition from searing sunlight to frigid darkness during each 90-minute Earth orbit had caused the telescope's aging solar arrays to oscillate, literally giving the observatory a case of the jitters.

"The situation was terrible," recalls former astronaut Jeffrey Hoffman, now a professor at the Massachusetts Institute of Technology (MIT).

Among other tasks, Hoffman and a crew of five other astronauts inserted tiny corrective mirrors in front of the

Hubble observations also showed that monster black holes grow in lockstep with the central distribution of stars in their home galaxy.

observatory's detectors, exactly compensating for Hubble's misshapen mirror.

Three weeks after the mission to correct the lens ended, on New Year's Eve 1993, Hoffman received a call from a senior STScI official. After wishing Hoffman a happy new year, the official asked Hoffman if he had a bottle of champagne handy. Images had just come down from the refurbished Hubble, he told Hoffman, and they were crystal clear.

First Compelling Evidence for Supermassive Black Holes

Astronomers immediately began reaping the benefits of the repaired Hubble. With Hubble's Faint Object Spectrograph, Holland Ford of Johns Hopkins University and his colleagues homed in on the suspected site of a supermassive black hole: the center of the giant elliptical galaxy M87, some 50 million light-years from Earth. The team clocked the speed at which a disk of hot gas near the galaxy's center whipped around the core.

The speed of the gas, about 550 kilometers per second, along with its central location, suggested that the spinning disk was being tugged by a massive, compact object—an object as heavy as 3 billion suns confined to a region no larger than our solar system. Only a supermassive black hole, an object whose gravity is so strong that not even light can escape its grasp, could fill the bill, the researchers concluded.

The finding was the first definitive confirmation for the existence of a giant black hole beyond the Milky Way galaxy. Soon Hubble, along with other telescopes, would find that the core of nearly every large galaxy houses such a gravitational beast. Hubble observations also showed that monster black holes grow in lockstep with the central distribution of stars in their home galaxy. Astronomers speculate that the jets and winds associated with black holes disrupt or expel star-forming gas, regulating galaxy growth.

A Comet Hits Jupiter

One of Hubble's earliest claims to fame came from observations in our own solar system.

In 1993, planetary scientists Gene and Carolyn Shoemaker and amateur astronomer David Levy discovered a comet called Shoemaker-Levy 9, which had been torn into pieces by a close gravitational encounter with Jupiter. Studies of the comet's orbit revealed that in July 1994, the fragments would smash into the gas giant.

At MIT, planetary scientist Heidi Hammel was unimpressed when a graduate student breathlessly relayed the news. "My reaction was 'Oh, please; Jupiter is huge, comets are tiny; nothing is going to happen.'"

Nonetheless, when a colleague calculated that the collisions could create dark plumes big enough to be seen in Jupiter's atmosphere, Hammel agreed to write a proposal to request Hubble time. Only a few weeks later, a still skeptical Hammel was told not only that her proposal was accepted but that she would coordinate other Hubble observations of the weeklong event.

At a press conference at STScI on 16 July, the Shoemakers and Levy were cautioning reporters that there might not be much to see. In the basement, huddled around a computer screen, Hammel; Melissa McGrath, a planetary scientist then working at STScI; and other planetary scientists scrutinized Hubble images of Jupiter as they were relayed to Earth.

One of the first pictures showed a black dot on Jupiter. Hammel thought the mark might merely be the shadow of Jupiter's moon Io. Then another image showed a big black plume rising above the planet.

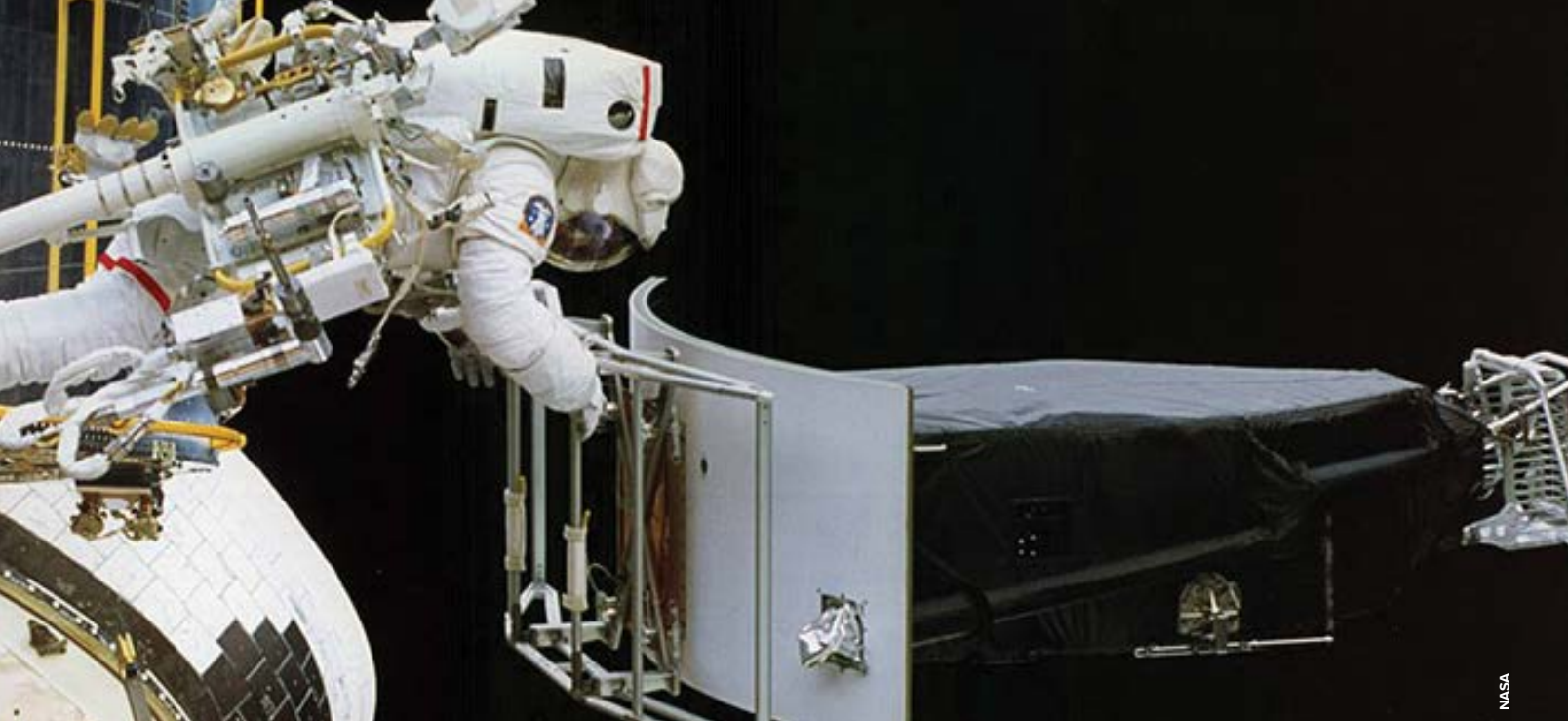
McGrath grabbed a bottle of champagne that she had brought, and Hammel hastily printed out a picture of the plume. Then they raced upstairs and interrupted the press conference. "It was so obvious that this was a major event, even on this ratty little computer printout," says Hammel. "We had to break in."

Gene Shoemaker stopped what he was saying while Hammel waved the photo from the podium. Then Shoemaker took a swig of champagne.



Impact sites moments after fragments of the comet Shoemaker-Levy 9 hit Jupiter in 1994.

H. Hammel, MIT; NASA/ESA



Astronaut Jeffrey Hoffman removes the Wide Field and Planetary Camera 1 during the first Hubble repair mission, which corrected for the telescope's flawed mirror, in December 1993.

The Jovian collisions “were a sort of perfect physics experiment that normally can’t be done in astronomy and planetary science,” says Hammel. “The dark material deposited by the comet fragments [was] akin to injecting ink into the atmosphere of Jupiter and then watching it trace out the atmospheric motion of the planet.”

The impacts enabled scientists to directly measure Jupiter’s wind speeds in the planet’s troposphere and stratosphere, Hammel says. The suite of small, medium, and large explosions created by the Shoemaker-Levy 9 impacts “also provided deep insight into multimegaton catastrophes on Earth like the dinosaurs experienced, and we humans may yet experience,” adds Hammel.

An Eye on the Outer Solar System

More recently, Hubble uncovered four additional moons of Pluto (the moons Nix and Hydra in 2006 and two additional small moons in 2011 and 2012). Before Hubble’s launch, planetary scientists knew about only one moon, Pluto’s large satellite Charon. The surprising complexity of the Pluto system revealed by Hubble will be explored close up when NASA’s New Horizons mission flies past the dwarf planet this July.

The observatory also used its ultraviolet sensitivity to observe auroras on Jupiter, Saturn, and Uranus beginning in the early 1990s. Auroras, like Earth’s northern lights, are generated when energetic charged particles, racing along a planet’s magnetic field lines, crash onto a planet’s upper atmosphere and cause the gases there to fluoresce.

Although the charged particles that cause the auroras on Earth, Uranus, and Saturn come from the solar wind, those on Jupiter have a different origin. Io, Jupiter’s volcanically active moon, supplies most of the particles for the Jovian aurora. Charged particles spewed by the moon’s volcanoes become trapped by Jupiter’s magnetic field, which rotates in synchronicity with the planet. The rotating magnetic

field creates strong electric fields at Jupiter’s magnetic poles, which accelerate the charged particles and generate the auroral ovals of light.

Joint observations of Saturn with Hubble and NASA’s Cassini spacecraft revealed where the auroras heat the planet’s upper atmosphere, accounting for the warmer-than-expected temperatures of the outer atmospheres of the giant planets despite their great distance from the Sun.

The Search for Exoplanets

Hubble has discerned the composition of planetary atmospheres beyond the solar system. To do that, Hubble (and other telescopes) relied on a rare alignment of parent star, planet, and the observatory. In that configuration, light from the star filters through the atmosphere of the

orbiting planet before it reaches the telescope. Atoms and molecules in the planet’s atmosphere absorb specific wavelengths of light, providing a spectroscopic fingerprint for the constituents of the gases shrouding the planet.

The fingerprints are extraordinarily faint, but the observatory was the first, in 2001, to find sodium and water vapor in the atmospheres of exoplanets. Ultimately, the technique will be used to search for biomarkers—signs of life—in the atmospheres of these planets.

Expanding Views

On a more cosmic scale, a team led by Wendy Freedman of the Carnegie Observatories in Pasadena, Calif., used Hubble’s newfound acuity to determine the size and age of the universe. The team relied on Hubble to find a group of bright yellowish stars, known as Cepheid variables, in the distant galaxy M100.

Cepheid variables have a unique property, periodically expanding and contracting, which changes their brightness in a regular pattern. In fact, the rate at which they pulsate or flicker is closely linked to their intrinsic bright-

A team used Hubble’s newfound acuity to determine the size and age of the universe.

ness: The slower they pulsate, the brighter they are. That makes Cepheid variables cosmic mile markers. By comparing their true brightness, as measured by their pulsation period, to their apparent brightness as observed in the sky, researchers could determine the distance to the galaxy in which the stars reside.

Obtaining accurate distances to ever more remote galaxies is a key to measuring the expansion rate and age of the universe. Freedman's team ultimately determined that the universe was about 13 billion years old. Previously, astronomers had pegged the age at somewhere between 10 billion and 20 billion years, with acrimonious debate about what number was correct.

Dark Energy

Nearly a decade later, in 2001, Hubble used another type of mile marker to corroborate one of the most astonishing discoveries ever made in cosmology.

Something was causing the expansion rate of the universe to speed up. That contradicted the prevailing view that the expansion rate had been continually slowing ever since the big bang because of the mutual gravitational tug of all the objects in the cosmos.

The unexpected finding, from ground-based telescopes, relied on a type of exploding star called a type 1a supernova. Because all type 1a supernovas have about the same intrinsic brightness, their appearance in the sky can be used to gauge the distance to their home galaxy.

However, the supernovas studied appeared about 20% dimmer than would be expected if the universe was slowing its expansion. It meant, astronomers said, that cosmic expansion had recently sped up and that the space between Earth and the supernovas had stretched out much more than anticipated.

Scientists did not know what caused the revved-up expansion, but they attributed it to something they call "dark energy"—a mysterious entity that pervades the entire universe and exerts a cosmic push, counteracting the pull of ordinary gravity. Some astronomers, however, were not convinced by the data. They worried that researchers might have been fooled by cosmic dust that made the supernovas look dimmer.

But there was a way to convince the skeptics.

If dark energy proponents were correct, the expansion rate began to rev up about 5 billion years ago. Before that time, the universe was smaller, and its density was greater—large enough that gravity's pull inward was much stronger than dark energy's push outward. At those earlier times, therefore, gravity's brake would have slowed down the expansion rate. In other words, before cosmic expansion sped up, there ought to have been a slowdown. Cosmic dust cannot mimic such a pattern.

Hubble found the type 1a supernovas that were distant enough to test this idea. These supernovas are so distant that the light now reaching Hubble was emitted by the explosion billions of light-years ago, revealing how the universe looked far back in time. In that early era, if the dark energy proponents were right, dark energy had not yet overwhelmed gravity's

tug and cosmic expansion was still decelerating. In charting the brightness of the nearby type 1a supernovas and the newfound, faraway ones, astronomers confirmed that the expansion rate had indeed slowed at earlier times.

The 2011 Nobel Prize in physics was awarded to three of the discoverers of dark energy: Saul Perlmutter of the Lawrence Berkeley National Laboratory in California, Brian Schmidt of the Australian National University in Weston Creek, and Adam Riess of the Johns Hopkins University in Baltimore and STScI.

Delving into the Past

Hubble's strong suit remains its ability to peer into the extremely distant past. Like all telescopes, Hubble acts like a time machine. Because it takes time for light to journey from a distant object to Earth, telescopes record an image of a galaxy not as it appears now but as it looked long ago, when the light left that galaxy. "Astronomy is the only science in which you can witness the past," says STScI astronomer Williams.

He ought to know. In 1995, as STScI director, he commanded Hubble to stare at a tiny, seemingly blank patch of sky for 10 days. That patch, known as the Hubble Deep Field, turned out to be chock-full of galaxies, some so distant that light left those starlit bodies when the 13.7-billion-year-old universe was only a few billion years old.

"The story of Hubble's deep fields is really the history of the universe over the last 90 percent of its lifetime," says STScI astronomer Jennifer Lotz.

Bucking traditional NASA policy, Williams decided to make the Deep Field data immediately available to all researchers, not just those who gathered the information. The data sharing became a new model for astronomers. "There's much more collaboration now...and it's much easier to get those discoveries out to the public because the information is not proprietary," says Williams.

Now and the Future

The Hubble Deep Field spawned several other ultradeep portraits that have collectively examined the evolution of

For more articles relating to the Hubble Space Telescope and the images it captures, visit <https://eos.org/articles>.



N. Smith (University of California, Berkeley) and NOAO/AURA/NSF

galaxies as far back in time as 700,000 years after the big bang, or about 7% of the age of the universe. Now astronomers want to go back farther, approaching what scientists call the cosmic Dark Ages—the era just before galaxies flooded the universe with light.

To do so, Lotz and her colleagues are making use of nature's own lenses—massive clusters of galaxies whose gravity bends the path of light rays from background galaxies that lie behind the clusters. As described by Einstein's general theory of relativity, the background light is magnified and brightened by the clusters, enabling Hubble to see distant galaxies 10 to 20 times fainter than it could otherwise detect.

Selecting six “frontier fields,” each containing a massive galaxy cluster, Lotz's team has begun peering back to earlier times and detecting smaller baby galaxies than had been possible to observe before. The findings promise to give a sneak peak of what Hubble's successor, the James Webb Space Telescope (JWST), will routinely accomplish with its much larger, 6.4-meter hexagonal mirror. JWST is scheduled for launch in late 2018.

An Enduring Legacy

Hubble's enduring success stems from the ability of scientists to adapt the instrument to answer new questions, notes NASA's Hubble project scientist Jennifer Wiseman. During five visits to the telescope between 1993 and 2009, astronauts essentially reinvented the observatory, updat-

ing it with state-of-the-art cameras and spectrographs that extended Hubble's sight to the infrared and increased its sensitivity at ultraviolet and visible light wavelengths. The servicing missions “have kept Hubble at the forefront of astrophysics for all these years,” she says.

With the space shuttle retired, there are no planned missions to repair the telescope ever again. So the primary task of astronomers such as Ken Sembach, head of Hubble operations at STScI, is to maintain the health of the telescope long enough to examine the heavens in concert with JWST. The new telescope has only infrared capabilities, whereas Hubble primarily studies the cosmos at visible and ultraviolet wavelengths, discerning structures JWST cannot detect.

Sembach is working with engineers to keep the observatory's electronics in the best shape possible. Although not every instrument on Hubble may still be working as time passes, “I'm very confident that we'll be able to operate until 2020,” he says.

What's more, each year that the telescope continues to operate, it will take an annual portrait of the solar system, looking for changes in the planets that might otherwise go unnoticed, says Hammel.

The discoveries Hubble may make during the next 5 years are anybody's guess. The observatory, says Williams, has taught astronomers a valuable lesson. “The universe is not only stranger than we think; it's stranger than we *can* think.”

Author Information

Ron Cowen, Freelance Writer



Third InterRidge Theoretical Institute

Magmatic and Tectonic Processes and Seabed Resources at Mid-Ocean Ridges

Hangzhou, China, September 25-27, 2015

The InterRidge Steering Committee is calling for contribution/participation to the Third InterRidge Theoretical Institute on “Magmatic and Tectonic Processes and Seabed Resources at Mid-Ocean Ridges” to be held in Hangzhou (<http://en.gotohz.com/>), China on September 25-27, 2015. The overarching goal of the theoretical institute is to synthesize the major international progress of the last decade, discussing new directions of advances, and enhancing future international collaboration as guided by the Third Decadal Plan (<http://www.interridge.org/thirddecade>). The following co-conveners will lead the scientific programs:

Theme One: Magmatic and Tectonic Processes

Dr. Jian Lin (Woods Hole Oceanographic Institution, USA), Co-Convenor

Dr. Marcia Maia (CNRS, France), Co-Convenor

Dr. Nobukazu Seama (Kobe University, Japan), Co-Convenor

Theme Two: Seabed Resources

Dr. Jiabiao Li (Second Institute of Oceanography, China), Co-Convenor

Dr. Sergei Silantyev (Vernadsky Institute of Geochemistry, Russia), Co-Convenor

Dr. Jérôme Dymet (CNRS, France), Co-Convenor

Travel funds will be provided by InterRidge for inviting international keynote speakers. Funds from China are also solicited to support the local meeting expenses.

Deadline for submitting title/abstract is July 15, 2015.

Deadline for pre-registration is August 15, 2015.

Webpage: <http://www.interridge.org/TheoreticalInstitute>.

Contact coordinator@interridge.org for questions.

AGU Sections and Focus Groups Announce 2014 Awardees

Horton Receives 2014 Ocean Sciences Voyager Award

Benjamin Horton received the 2014 Ocean Sciences Voyager Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award is given to a midcareer scientist (10–20 years post-degree) in recognition of significant contributions and expanding leadership in ocean sciences.



Benjamin Horton

Citation

It gives me great pleasure to introduce Dr. Benjamin Horton as the recipient of the inaugural AGU Ocean Sciences Voyager Award.

Ben's research focuses on the mechanisms and nature of past sea level changes, including those associated with earthquakes, tsunamis, and storms, to understand how these processes will impact future coastal environments. Ben has rapidly distinguished himself as a leader both within and beyond his discipline.

Certainly, the impact and quality of Ben's publication record alone qualifies him for the Voyager Award. Beyond the high quality and sheer number of his scholarly contributions, Ben exemplifies many additional qualities that speak to his promise for continued leadership in ocean sciences, including his talent as an educator—both within academia and beyond—and as a leader in interdisciplinary science teams. Ben has built a highly successful research group, and he did so at an impressive speed. There is no doubt that Ben already has had a significant impact on coastal science in the United States in terms of training sea level scientists of the future. Ben is also a very talented public speaker, and despite his intense research activity, he devotes an impressive amount of time to outreach, which is an increasingly important role for climate scientists of our generation. Ben has also developed a very strong network of interdisciplinary collaborators and is particularly effective in designing and implementing collaborative research programs that go well beyond his personal areas of expertise and extend worldwide.

I would like to conclude by saying that Ben has emerged as one of the most energetic and productive Quaternary scientists of his generation. His accomplishments as a scholar, as an educator, and as a citizen of the ocean sciences community make him more than deserving to receive the Voyager Award. Please join me in congratulating Ben on his accomplishments.

—Andrea Dutton, University of Florida, Gainesville

Response

Thank you very much, Andrea, and my most sincere thanks to AGU and the Ocean Sciences section for the Voyager award; I am deeply honored. This award recognizes the students, colleagues, and mentors who have always been supportive of me, both professionally and personally, throughout my career.

I would particularly like to thank Andy Plater, who saw my potential as an undergraduate at Liverpool University, and my graduate advisors, Ian Shennan and Antony Long at Durham University, who not only had the most amazing knowledge and understanding of Quater-

nary Science but were also patient men, allowing me to find my way as I began to understand the theory of sea level change. A decade ago, I moved the United States, where I met a new set of wonderful colleagues. These include Steve Culver, Jeff Donnelly, Alan Nelson, Daria Nikitina, Dick Peltier, and Tor Tornqvist. I also wish to make a special mention of the late Fred Scatena and Orson van de Plassche, whose influence on my scientific career lives on.

I have been very fortunate to work with a number of young, motivated postdoctoral scientists and graduate and

undergraduate students, most notably Andy Kemp and Simon Engelhart. These interactions were pivotal in shaping the research questions we ask in the sea level research community. My career has benefited enormously from field meetings and workshops through the International Geoscience Programme and the Paleo-constraints on Sea-level rise (PALSea) working group, by generating open debate and different perspectives on observations, analyses, and interpretations. I am also indebted to colleagues who have helped me become actively engaged at the interface between science and society.

But I would not have received this award if I had not had the support of my family, who remind me every day what matters in life. The final mention goes to my dad, Professor Peter Horton FRS, who is my inspiration.

—Benjamin P. Horton, Rutgers University, New Brunswick, N.J.

Neish Receives 2014 Ronald Greeley Early Career Award in Planetary Science

Catherine Neish received the 2014 Ronald Greeley Early Career Award in Planetary Science at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes significant early career contributions to planetary science.



Catherine Neish

Citation

The Greeley Early Career Award is named for pioneering planetary scientist Ronald Greeley. During his lifetime, Ron was involved in nearly every major planetary mission and was extraordinarily active in service to the community. Ron's greatest legacies, however, are those he mentored, and it is young scientists whose work and promise

we seek to recognize. This year's Greeley award winner is Catherine Neish, an assistant professor at the Florida Institute of Technology. Catherine received her Ph.D. from the University of Arizona in 2008 and, after a postdoctoral stint at NASA Goddard, joined the faculty at Melbourne in the Department of Physics and Space Sciences.

Catherine specializes in planetary surface properties, and she is ecumenical in choice of target, having written papers that incorporate data from eight different planetary bodies: Mercury, Venus, Earth, the Moon, Europa, Ganymede, Titan, and Triton. This certainly embraces the spirit of the Greeley award, as Ron was someone who was interested in the whole of planetary science, not just a single planetary body.

Catherine is expert in the use of orbital radar observations and has used these with optical imaging and topography to thoroughly revise our understanding of impact melt flows. She has also proposed that craters at high latitudes and low elevations on Titan are not simply buried by later sediments but form flatish to begin with, in a manner similar to craters formed on Earth in soft, oceanic sediments.

But not all of Catherine's work is remote sensing based. Her Ph.D. thesis had three doctor-fathers: Ralph Lorenz, Jonathan Lunine, and Mark Smith. Her papers with them on the astrobiological potential of Titan and the lab work that went into them are notable. The relative ease in which biological molecules such as amino acids can form in ammonia-infused "Titan primordial soup" suggests (as if we needed reminding) that life may be ubiquitous in the universe. One suspects such work will have long-lasting impact.

Congratulations to Catherine D. Neish, the 2014 recipient of the Ronald Greeley Early Career Award in Planetary Science.

—William B. McKinnon, Washington University, St. Louis, Mo.

Response

I have always greatly admired the curiosity that Ron Greeley showed for all the many wonders of the solar system. I work in many diverse fields, and every time I start a new project, I see Ron's influence there. His willingness to study new processes on a range of planetary objects makes him the type of planetary scientist that I endeavor to be. I hope to continue to follow in his footsteps as I progress in my career and am deeply honored to receive this award that bears his name.

I would also like to take this opportunity to thank all of those who have supported me throughout my career. Science is not a solitary enterprise, and I have benefited greatly from the advice and wisdom of a great many people. Thanks to Ellen Howell and Mike Nolan for introducing me to planetary

radar, a passion that has guided my career. Thanks to the entire community of graduate students, postdocs, and faculty at the Lunar and Planetary Laboratory for fostering my curiosity for planetary science. I would especially like to thank the incoming class of 2004 for their friendship and Ralph Lorenz,

Jonathan Lunine, Mark Smith, and Árpád Somogyi for guiding my Ph.D. research. Thanks also to my colleagues at the Applied Physics Laboratory and Goddard Space Flight Center for helping an inexperienced postdoc transform into a confident scientist. Finally, I would like to thank my parents for

their unwavering support and my husband, Shawn, for constantly pushing me to be my best. I share this award with them.

—Catherine Neish, *Florida Institute of Technology, Melbourne*

Soderblom Receives 2014 Whipple Award

Laurence A. Soderblom received the 2014 Whipple Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes an individual who has made an outstanding contribution in the field of planetary science.



Laurence A. Soderblom

Citation

The Whipple Award is the highest honor given by the AGU Planetary Sciences section and is named for Fred Whipple, a famed space scientist and the preeminent cometary scientist of the mid-20th century. This year's Whipple Award goes to Larry Soderblom of the U.S. Geological Survey Astrogeology Science Center in Flagstaff.

Larry is the consummate planetary scientist. A geophysicist by training and a geologist by inclination, his work is of extraordinary breadth. Over a more than 4-decade career in planetary science, he has participated in more than a dozen planetary missions ranging spatially from Venus out to Neptune and all the planets (and several minor bodies) in between. Scientifically, he is a generalist, but more precisely, he is better thought of as a specialist in dozens of subfields. His work is rigorous, quantitative, mindful of complexities yet always strives to maximize the science.

Notably, only in his thirties, Larry was deputy Imaging Team leader for the Voyager mission, overseeing that first scientific exploration of the satellites of the outer solar system; today, he is interdisciplinary scientist for satellites for Cassini-Huygens. And there is a direct connection to Fred Whipple's work: Larry led the development of the camera/spectrometer for the experimental Deep Space 1 mission. The images returned of comet Borrelly were our first clues to the geologic complexity of comets now gloriously revealed by Rosetta.

Larry's exceptional abilities have made him a target for leadership positions, and he has done extraordinary service for the community. He served twice as branch chief in Flagstaff and chaired expertly and effectively various working groups, subcommittees, and committees for NASA. And most recently, he was vice-chair of the Planetary Science Decadal Survey for the National Academy.

Finally, Larry is exceptional for his humanity and his willingness to mentor younger scientists. Larry is a model of unselfish cooperation in research, indeed, an exemplar of wisdom and humor in the midst of scientific discovery and its inevitable controversies.

Congratulations to Laurence A. Soderblom for a lifetime of outstanding contributions to planetary science.

—William B. McKinnon, Washington University in St. Louis, St. Louis, Mo.

Response

I am most grateful to all of my scientific friends and colleagues, to be recognized with this year's Whipple Award. Through my career I have been so fortunate to participate in an eye-opening journey of exploration across our solar system—a journey that began for me in the late 1960s. I am deeply indebted to my two Ph.D. thesis advisers, Bruce Murray and Gene Shoemaker, for encouraging me and for setting me onto this mind-bending path. I have been truly privileged to participate in the first stage of exploration of the outer solar system and witness firsthand the explosion in our understanding of planets and planetary processes, as it has so rapidly unfolded.

When the Voyager missions were started, our vision of what lay ahead in our adventure to explore the outer planets and satellites of our solar system was primitive and unimaginative. Most expected the moons of the giant planets to be battered, lifeless, and geologically dead. But over the last 45 years, our view of these worlds has exploded with a panoply of unimaginably beautiful and complex activity. Plumes, geysers, molten calderas, rain, rivers, lakes, and seas popped up from Mars to comets to Io to Enceladus to Titan to Triton. What lessons can we take from these active places into the next phase of exploration? When the Voyagers were launched, our naiveté allowed that only planet Earth was dynamically active. But exploring our solar system, our cosmic backyard, has awed us with unforeseen complexity, scientific beauty, and rich activity. We are now far better poised for our nascent exploration of the worlds beyond that backyard.

—Laurence A. Soderblom, *U.S. Geological Survey, Flagstaff, Ariz.*

McLaskey Receives 2014 Keiiti Aki Young Scientist Award

Gregory C. McLaskey received the 2014 Keiiti Aki Young Scientist Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes the scientific accomplishments of a young scientist who makes outstanding contributions to the advancement of seismology.



Gregory C. McLaskey

Citation

Gregory C. McLaskey earned his B.S., magna cum laude, in civil engineering from Cornell University and his master's and Ph.D. degrees from the University of California, Berkeley, the latter in 2011. In grad school he was awarded a National Science Foundation Graduate Research Fellowship. He then spent 3 years at the U.S. Geological

Survey (USGS) in Menlo Park on a Mendenhall Postdoctoral Fellowship. This fall he began a faculty position at Cornell in the School of Civil and Environmental Engineering.

Greg has derived new insights on earthquake physics through a series of innovative experimental studies. Using a direct shear apparatus that he designed and built, including transducers that are calibrated with Green's functions for the experimental geometry, he found that laboratory-generated earthquakes with longer recurrence intervals generate more high-frequency energy (McLaskey et al., *Nature*, 2012). This relationship is also seen for small natural earthquakes and suggests that fault healing time plays a role in determining earthquake spectra.

In his postdoctoral work on the large-scale rock friction apparatus at the USGS in Menlo Park, Greg found that clus-

ters of high-frequency foreshocks can occur in a slowly slipping patch of the experimental fault if the rate of applied local shear stress is high enough, suggesting that the transition between aseismic and seismic slip is modulated by the local stress field (McLaskey and Kilgore, *Journal of Geophysical Research*, 2013). Another striking result is that populations of tiny seismic events (magnitudes of -6 to -7) have stress drops that are comparable to larger natural earthquakes (McLaskey et al., *Pure and Applied Geophysics*, 2014). This result indicates that stress drop is independent of seismic moment, a concept proposed by Keiiti Aki.

Greg is now building an experimental lab at Cornell, and his unique blend of seismology and rock friction studies has great potential to further our understanding of the physics of earthquake faulting.

—Karen M. Fischer, *Brown University, Providence, R.I.*

Response

I am deeply honored to receive this year's Aki award. I would like to thank my graduate adviser, Steve Glaser, for creating such a great experimental laboratory and for the freedom to "play" with seismology in that lab. It was by experimenting with different materials, sensors, and laboratory seismic sources such as ball impact and fracture that I was able to build my intuition about the way seismic waves are generated and propagated. I would also like to thank Roland Bürgmann

for broadening my view of Earth science, for his encouragement, and for welcoming me in his lab meetings. Finally, I would not be where I am today without my fantastic colleagues and mentors at the earthquake science center at the USGS in Menlo Park. In particular, Nick Beeler was supportive of me from day one. Brian Kilgore: thanks for not letting anyone retire that 2-meter apparatus and for dedicating so much time to it. Dave Lockner: it has been so exciting to work with you and to write papers together. I look forward to continuing laboratory earthquake experiments that explore more closely their physics, mechanics, and scaling relationships.

—Gregory C. McLaskey, Cornell University, Ithaca, N.Y.

Qin Receives the 2014 Fred L. Scarf Award



Jianqi Qin

Jianqi Qin has been awarded the Fred L. Scarf Award. This award is given to an honoree in recognition of an outstanding dissertation that contributes directly to solar-planetary science. Qin's thesis is entitled "Numerical modeling of the inception, morphology and radio signals of sprites produced by lightning discharges with positive and negative polarity." He was

formally presented with the award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif.

Jianqi received his B.S. and M.Sc. in physics from Nanjing University in 2006 and 2009, respectively, and received a Ph.D. in electrical engineering from the Pennsylvania State University in 2013. He is currently working as a postdoctoral scholar in electrical engineering under the supervision of Victor P. Pasko at the Pennsylvania State University in University Park. His research interests include computational plasma physics, atmospheric and space electricity, and gas discharge physics.

Scherrer Receives 2014 Space Physics and Aeronomy Richard Carrington Award

Deborah Scherrer received the 2014 Space Physics and Aeronomy Richard Carrington Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award is given in recognition of significant and outstanding impact on students' and the public's understanding of our science through education and/or outreach activities.



Deborah Scherrer

Citation

Deborah Scherrer is the finest example of a professional deserving of the Space Physics and Aeronomy Richard Carrington (SPARC) Award. She is a long-time AGU member who has had (and continues to have) a significant and far-reaching impact on public and student understanding of space physics and aeronomy on a local,

SID monitors are now deployed at over 900 sites around the planet where high school students and teachers are using them as the centerpiece of authentic research experiences that develop new capacities and awareness in space physics and aeronomy science. The program is being sustained as part of the United Nations' (UN's) International Space Weather Initiative where it supports UN aims to cultivate new space science capacities and interests in developing regions of the world.

—Cherilynn A. Morrow, Aspen Global Change Institute, Basalt, Colo.

Response

Many of you were passionate about science as a child. You probably had tremendous parental support and the

encouragement of teachers, family, and friends who bought you telescopes and tools. You went to the "right" schools, got your Ph.D., and here you are. That is not my story. As a kid, I was passionate about astronomy. But there were no role models, no mentors, no supportive parent, no resources, no encouragement from teachers, and the college I wanted to attend (the California Institute of Technology) didn't accept women at the time. I did go to college and graduate school and had a fine career in computer science, but my passion for astronomy lingered. One day, thanks to

my wonderful and supportive husband, Phil Scherrer, I quit my high-paying high-tech job in Silicon Valley and moved to Stanford to develop solar science education programs for NASA.

Never have I been happier or more rewarded—working with underserved teachers and students all over the world who just want a chance to learn, to participate in science. I am so thankful to have had these opportunities. I've been mentored by the best, including Cherilynn Morrow and Pat Reiff, two other SPARC award winners, and I've worked with outstanding scientists, educators, and students whose enthusiasm for science is boundless. I am humbled and proud to be among them and to have had the opportunities in this amazing career.

I am especially here for the students, the ones like me, who didn't get the chances. I believe every child has the birthright of access to science knowledge and understanding the universe we live in. Thank you, dear friends, for recognizing me with this award and for giving me these glorious opportunities to share the joy and excitement of solar and space science!


—Deborah Scherrer, Stanford University, Stanford, Calif.

national, and *global scale*. There is no one in the field today who can match the sustainable *worldwide* impact of her achievements.

I have known Deborah professionally for over 15 years and have enjoyed the privilege of serving with her on pioneering projects to embed successful education programs in scientific research environments, to provide support for scientists contributing to education, and to bring the wonders of solar and space physics to underserved teachers and students in the United States and around the world.

Deborah is the founder of the Stanford SOLAR Center and director of its highly successful educational programs and award-winning website, in association with NASA solar spacecraft missions. From my perspective as a cocreator of NASA's (then) progressive Education and Public Outreach (E/PO) policy for space missions, Deborah's vision in developing the SOLAR Center's innovative framework helped to operationalize and exemplify what a successful space mission education program could be.


Especially notable among Deborah's many accomplishments is her leadership of a project to distribute scientific instrumentation (sudden ionospheric disturbance (SID) monitors) to high school students worldwide. The monitors are very low frequency receivers that detect solar influences on the Earth's ionosphere. The project to distribute and support the use of SID monitors was greatly enhanced as part of her catalytic role in developing the education program of the International Heliophysical Year (IHY).



AGU Blogosphere

AGU proudly welcomes

From a Glacier's Perspective



Written by glaciologist Mauri Pelto, this blog examines the response of glaciers to climate change one glacier at a time.

blogs.agu.org

Bosco Receives 2014 Basu Early Career Award in Sun-Earth Systems Science



John Bosco

John Bosco has been awarded the Sunanda and Santimay Basu Early Career Award in Sun-Earth Systems Science. The award recognizes an individual scientist from a developing nation for making outstanding contributions to research in Sun-Earth systems science that further the understanding of both plasma physical processes

and their applications for the benefit of society. Bosco's thesis is entitled "A contribution to TEC modelling over southern Africa using GPS data." He presented a talk and was formally presented with the award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif.

John Bosco received his B.S. in physics and mathematics with education from Mbarara University of Science and Technology, Uganda, in 2004, B.S. Honors in astrophysics and space science at the University of Cape Town, South Africa, in 2005, and a M.Sc. in space physics from Rhodes University, South Africa, in 2008 under the supervision of Lee-Anne McKinnell and Pierre Cilliers. He received a Ph.D. in space physics from Rhodes University, South Africa, in 2011 under the supervision of Lee-Anne McKinnell and Ben Opperman.

He is currently working as a researcher within the space science and applications group at the South African National Space Agency, Hermanus, South Africa. His research interests include ionospheric modeling and characterization, ionospheric electrodynamics, observational data analysis on traveling ionospheric disturbances (including mapping), and other space weather-related studies.

Schaeffer Receives 2014 Study of the Earth's Deep Interior Focus Group Graduate Research Award



Andrew Schaeffer

Andrew Schaeffer received the 2014 Study of the Earth's Deep Interior Focus Group Graduate Research Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif.

Andrew Schaeffer received his B.Sc. in geophysics from the University of British Columbia in 2006 and a M.Sc. in seismology from the University of British Columbia in

2009. He recently completed his Ph.D. in global surface wave tomography under the supervision of Sergei Lebedev and Chris Bean jointly at the Dublin Institute for Advanced Studies and University College Dublin in Dublin, Ireland. His research focuses on the structure and dynamics of the Earth's upper mantle and transition zone, imaged using surface wave tomography, receiver functions, and geodynamic modeling.

Evans Receives 2014 Basu United States Early Career Award for Research Excellence in Sun-Earth Systems Science



Rebekah Evans

Rebekah Evans received the 2014 Basu United States Early Career Award for Research Excellence in Sun-Earth Systems Science at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. This award is given annually to one early career scientist (no more than 3 years post-degree) from the United States in recognition of significant work that shows the focus and promise of making outstanding contributions to research in Sun-Earth

systems science that further the understanding of both plasma physical processes and their applications for the benefit of society.

Rebekah Evans received her B.S. in physics from the University of Delaware in 2006 and a M.Sc. and Ph.D. in physics from George Mason University in 2011 under the supervision of Merav Opher. From 2011 to 2014 she participated in the NASA Postdoctoral Program in the Heliophysics Science Division of Goddard Space Flight Center. She is currently working as a physics teacher in Fort Worth, Texas. Her research interests include the heating and acceleration of the solar wind and the evolution of solar eruptions.

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Fulton Receives 2014 Jason Morgan Early Career Award

Patrick Fulton received the 2014 Jason Morgan Early Career Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award is for significant early career contributions in tectonophysics.



Patrick Fulton

Citation

The AGU Tectonophysics section is pleased to present the 2014 Jason Morgan Early Career Award to Patrick Fulton for his fundamental contributions in the fields of fault mechanics and earthquake energetics. In the time since his Ph.D., Patrick has amassed an exceptional research record and has established himself internationally as a leader in measuring the frictional dynamics of faults. He has also emerged as a leader and statesman for a cohort of early career scientists and as an effective and accomplished mentor.

Patrick's success can be traced in large part to his extraordinarily broad and deep expertise in numerical modeling, field data collection, and analysis of laboratory data. In his Ph.D. research focused on the San Andreas heat flow paradox, Patrick conducted a series of numerical modeling experiments to clarify arguments for a low friction fault and to rigorously investigate the role of fluid overpressures in fault weakening. As a postdoc with Rob Harris at Oregon State University and then with Peter Flemings at the University of Texas, Patrick brought his considerable quantitative skills to analyses of laboratory friction experiments, vitrinite reflectance data as indicators of frictional heating, gas hydrate dynamics, and geodetic and marine heat flow data. Most recently, as a research scientist at the University of California, Santa Cruz, Patrick has taken the

lead in the temperature observatory for the International Ocean Discovery Program (IODP) Japan Trench rapid response drilling (JFAST) project. The results have, for the first time, resolved the coseismic friction on a major fault and show that it is much lower than previously thought.

As is evidenced in all of his work, Patrick attacks complicated numerical problems efficiently and with keen foresight and identifies connections between his results and the broader geological context that have not been obvious to others. We look forward to his continued success at solving major geophysical problems with his unique and thoroughly modern toolkit.

—Demian Saffer, *Pennsylvania State University, University Park*; and Emily Brodsky, *University of California, Santa Cruz*

Response

I am deeply honored to receive this award. The kind citation reminds me of how grateful I am to have so many great mentors. I would particularly like to thank and acknowledge Demian Saffer, Rob Harris, Peter Flemings, and Emily Brodsky. Their encouragement and support have given me a

great freedom to develop into the scientist that I am today; I continue to look up to them in many ways.

I would also like to thank Fred Chester and Jim Mori, the cochiefs of the Japan Trench Fast Drilling Project. They succeeded in the tremendously difficult job of leading a tremendously difficult project, and I am thankful for their belief in our ability to do impossible things and the encouragement that they, and the IODP program in general, have provided to so many early career scientists such as myself.

Likewise, I would also like to thank my other colleagues and collaborators, including the rest of the JFAST team both offshore and on and the others with whom I have had great joy working with over the years and have learned from considerably.

I am also grateful to have had the opportunity to work with a number of great students. Their hard work and inquisitiveness keep me on my feet and continually remind me of how wonderful a field of science it is that we explore.

Lastly, I would like to thank my family and friends, who have made this life of science and exploration fulfilling even when times are hard and stressful. This award further stokes my desire to do good work. It also inspires me to continue to help other upcoming scientists and students feel as welcome and encouraged within this community as I do.

Thank you very much.

—Patrick Fulton, *University of California, Santa Cruz*

Jackson Receives 2014 Hisashi Kuno Award

Matthew Jackson received the 2014 Hisashi Kuno Award at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes “accomplishments of junior scientists who make outstanding contributions to the fields of volcanology, geochemistry, and petrology.”



Matthew Jackson

Citation

Matt Jackson was a student of Stan Hart at Massachusetts Institute of Technology (MIT)/Woods Hole Oceanographic Institution (WHOI) who pioneered the use of intraplate volcanism to investigate the structure and causes of mantle chemical heterogeneity.

Matt's work has well shown how much fundamental information

remains to be extracted from the compositional variations in intraplate volcanism. His thesis involved very fine scale laser ablation isotope analysis of melt inclusions from Samoa and confirmed that the radiogenic signature derives from recycled crust in the mantle source of these lavas. Matt and student Rita Cabral recently again used micron-scale measurements to detect processes operating over gigayear timescales and whole-mantle circulation when they found mass-independently fractionated sulfur, which had once been in the Archean atmosphere, in modern igneous sulfides. In between these discoveries, he stepped back in scale to use whole-rock compositional variations to document that some large igneous provinces derive from a mantle source formed within <200 million years of Earth formation. In work with a previous Kuno Award winner, Raj Dasgupta, Matt showed that the mantle compositional reservoirs defined by Stan Hart using trace elements and isotopes are expressed as well in major element composition, which has critical consequences for the dynamic behavior of the different components during their circulation through the mantle. Matt showed that the bipolar Kea-Loa chemical signature seen in Hawaii is common to many other hot spot traces, with implications for the way that hot spots sample the deepest parts of the mantle. Matt's success reflects his energy and enthusiasm, a well-developed ability to converse, impressive analytical talents, and, perhaps most importantly, his ability to see in, and extract from, complex data sets the answers that they contain to fundamental questions in solid Earth science. His research focus and magnitude of achievement make him a most deserving recipient of an award named in honor of Hisashi Kuno.

—Rick Carlson, *Carnegie Institution for Science, Washington, D. C.*

Response

Thank you, Rick, for your kind words, and for all of your support. And thanks to the Kuno committee and to my nominators for this truly unexpected award. This is an auspicious way to start my career with a terrific bunch of colleagues at the University of California, Santa Barbara.

I want to thank a few of the people that have inspired me to pursue geochemistry and have fun doing so. Phil Ihinger and the late Karl Turekian inspired me to pursue research at Yale, and after working in Phil's lab, I was “fired up” about studying hot spot volcanism in graduate school.

So I signed up for 5 years with Stan Hart at the WHOI-MIT Joint Program, and working with Stan was a lot of fun. In fact, Stan often described doing geochemistry as “having fun,” and the philosophy stuck. I cannot imagine working with a

more supportive graduate adviser. Rounding out the geochemical “dream team” were Nobu Shimizu and Mark Kurz, and a lot of really neat ideas were born during conversations in their offices.

Al Hofmann seemed to be ever present and was not shy about keeping me in line!

My postdoc at Carnegie continued the fun started at WHOI. Rick Carlson was supportive of exploring a lot of neat ideas, and I consider myself lucky to have his mentorship. Steve Shirey and Erik Hauri completed the ideal trio of mentors and created a fantastic postdoc experience.

Now I have students of my own, and they are teaching me how to have even more fun: Rita Cabra, Ellie Price, Julie Klath, and Floyd Jaggy. I am lucky to work with each of you.

My family has been incredibly supportive, and I am here today because of my family's role in my life. My wife, Anna, has been my closest ally and friend and my strongest supporter. None of this would have been possible without you.

—Matthew Jackson, *University of California, Santa Barbara*

Ghiorso and Sack Receive 2014 Norman L. Bowen Award

Mark Ghiorso and Richard O. Sack received 2014 Norman L. Bowen Awards at the 2014 AGU Fall Meeting, held 15–19 December in San Francisco, Calif. The award recognizes outstanding contributions to volcanology, geochemistry, or petrology.



Mark Ghiorso

Citation for Mark Ghiorso

Ms. President, thank you. First of all, Mark, thanks for inviting me to be part of this night when we celebrate your career and the use of quantitative thermodynamic models to understand magmatic processes. It is a great pleasure to be here.

Mark is part of a generation of petrologists who worked with Ian Carmichael at Berkeley. From that amazing nursery of talent, Mark emerged as the leading force in the development of thermodynamic models of magmas and coexisting minerals. Mark proceeded to develop a comprehensive description of the phase relations between minerals and melt in magmas, an effort that took some 15 years to yield its first version. That Mark pursued this is a testament to his vision and perseverance. Albeit imperfect, MELTS allows us to rigorously model the evolution of magmas and the associated mineral and volatile assemblages. The 1995 paper alone has drawn more than 1500 citations, and altogether, Mark's work has drawn

more than 6000 citations. These are not empty metrics; they are a clear demonstration that MELTS has become part of the modus operandi of petrology and geochemistry and of the tremendous influence of his work.

But Mark is much bigger than MELTS. Mark is an incredible teacher, as you could see this morning in full display. Mark is a fabulous mentor. I cannot overstate his influence in my own career. His students include two former Bowen awardees and a Macelwane awardee, one of whom is about to also receive the Mineralogical Society of America's Dana Medal. Such a track record of mentorship is worthy of an award by itself.

Mark has always had the clarity and vision to understand that computational thermodynamics is just a tool to address important scientific questions. From partial melting in the mid-ocean ridges, to the phase relations in the deep mantle, to the evolution of silicic magmas in the shallowest crust, Mark has been involved in work that has greatly influenced our thinking.

It could not be more fitting for Mark to receive the Bowen Award. First, Mark's work builds directly on the legacy of experimental petrology mastered by Bowen. Secondly, Mark has been a fundamental contributor to the effort of putting such experimental work onto solid theoretical footing.

Finally, Mark has managed to create the tools that allow every petrologist to perform calculations that are unfathomable to most of us. And he has done so while addressing fundamental problems in petrology and geochemistry.

I wish Mark had dedicated some of his time to the cloning business because we could use a few more copies of him. But he is not looking back at his career; he's looking forward, creating unbelievably clever and powerful methods to address petrologic problems, as he says, at the speed of thought. We have been incredibly fortunate to have Mark devote his time and energy to petrology and geochemistry, and we can be assured of many more productive years in his career.

Members of the Volcanology, Geochemistry, and Petrology (VGP) section, it fills me with tremendous joy to call all of you to join me in congratulating Master Ghiorso as he receives a 2014 Norman L. Bowen Award.

—Guilherme A. R. Gualda, *Vanderbilt University, Nashville, Tenn.*

Response

It is both exhilarating and humbling to be awarded an honor named after Norman L. Bowen. I can't help but ask, "What would Bowen think about this choice?" Would he be appalled, indifferent, or intrigued? I hope that his response would be the last.

I was both an undergraduate and graduate student at the University of California, Berkeley, during the 1970s. I went to Berkeley because it was the local school, because tuition was essentially free, and because I was fascinated as a high school student with hot springs, volcanos, and, in particular, the work of Howell Williams and Arthur L. Day. Day was no longer living, but Williams was still alive and at Berkeley. I got to Berkeley and began to take courses from Garnis Curtiss and Charles Gilbert and this young guy with a funny cockney accent named Ian Carmichael. Then, as a junior I took a class from Hal Helgeson. That changed my life because I discovered in Hal the style of scientific pursuit that I wanted to spend the rest of my life doing. I stayed at Berkeley for graduate school, deciding to work with Ian. It has always been important to me to work with people who have a sense of humor. Carmichael had a brilliant mind, an uncanny ability to motivate and mentor students, but most of all he had a great sense of humor.

At Berkeley my fellow graduate students included Charlie Bacon, Wes Hildreth, Frank Spera, Gail Mahood, Jim Luhr, Jon Stebbins, and Mark Rivers. I thought it was normal to be surrounded by intellect of this caliber, and I did not realize how lucky I was. I took courses from Leo Brewer, Ken Pitzer, and Jon Prausnitz, and I was able to hover about Helgeson as he completed his seminal synthesis of the thermodynamic properties of aqueous solutions and the rock-forming minerals.

Ian Carmichael ignited my interest in the thermodynamics of silicate melts, and he shared with and encouraged the work which has occupied me since that time. Ian introduced me to Richard Sack, from whom I learned all about the thermodynamics of solid solutions. That was another extraordinary stroke of luck, as was working with Ed Stolper, whose generosity of spirit stands out as a high point in my career.

I want to thank the faculty at the University of Washington, where I worked for 23 years, especially my first two chairs, John Adams and Tom Dunne, for encouraging me to

do what I do even if I could not get it funded. In addition, I thank my extraordinary students Peter Kelemen and Marc Hirschmann for their gifted insights and my consummate experimental colleague Victor Kress. I have since 2005 had the great fortune of working with Guil Gualda, who introduced me this evening. That collaboration has been so much fun that I hope it never ends. I want to thank him for nudging me to work on silicic magmas that I never thought would be so fascinating.

It is a wonderful thing to receive the Bowen Award, and I sincerely thank the committee and the VGP membership for selecting me for this magnificent honor.

—Mark Ghiorso, *OFM Research, Redman, Wash.*



Richard O. Sack

Citation for Richard O. Sack

I am very pleased and honored to introduce Richard Sack, the corecipient of this year's Norman L. Bowen Award of the AGU. This award is given annually to individuals who have made outstanding contributions to volcanology, geochemistry, or petrology. Richard Sack is certainly one of those unique scientists.

His work on the thermochemistry of sulfides proved that experiment and theory have relevance to studying ore deposits. After a decade of sulfide work, Richard returned to solid solutions found in meteorites, most recently, to those relevant to the petrogenesis of calcium-aluminum inclusions in carbonaceous chondrites, defect spinels, and now fassaites. In addition, Richard Sack's and Mark Ghiorso's publications on thermodynamics of multicomponent pyroxenes have provided new understanding of the phase relations of these complicated but extremely important mineral systems.

Richard has been an affiliate faculty member of the Department of Earth and Space Sciences of the University of Washington since 1993, and he founded the not-for-profit OFM Research Corporation with Mark Ghiorso in 2005. Richard provided experimental data and constructed solution models for minerals to calibrate the SILCAL model, predecessor of MELTS. Mark and Richard collaborated to produce thermodynamically viable models for minerals, which led to the calibration of the original MELTS software. Mark Ghiorso and his coworkers afterward produced many variants and improvements in models for silicate melts in the code. This is truly a significant scientific contribution to a quantitative understanding of mineral-melt systems. More than a quarter of a million visits in 2014 alone show the global interest in this software. Norman Bowen would doubtless have loved to check his experimental results against the output of the MELTS.

It is my great pleasure and honor to present to you my friend and colleague, the 2014 Norman Bowen Award corecipient, Dr. Richard Sack.

—Attila Kilinc, *University of Cincinnati, Cincinnati, Ohio*

Response

Thank you, Attila! I am pleased to accept this Norman Bowen Award on behalf of all the individuals who helped me achieve this recognition. My parents, Bernhard and Mary, and brother, John, are high on this list, as are Ron Brown and Leo Matthew Hall, who introduced me to chemistry and mineralogy, and Philip R. Whitney, who introduced me to coronas in Adirondack mafic granulites and persuaded me to continue my studies in metamorphic petrology with James B. Thompson Jr. During these studies I met many interesting characters, including Tim Grove, Mike Mottl, Barbara Luedtke, Nicolas DarBois, Steve Bushnell, Ed Stolper, and Dave Walker. I am forever in the debt of Dave, Ian Carmichael, and Jim Thompson for arranging for the postdoc that enabled me to meet Hal Helgeson, Peter Lichtner, and the MELTS architect, my colleague at OFM Research and long-term collaborator, Mark Ghiorso.

I also thank Attila Kilinc, Atilla Aydin, Cliff Kubiak, Dave Gaskell, Arvid Johnson, Tom Tharp, Mark Ghiorso, Marc Hirschmann, Bruce Nelson, Nick Hayman, John Fitzpatrick, and Bill and Betty Clinkenbeard, Scott Kuehner, Carl Hager, Dave McDougall, Ed Mulligan, Jamie Allan, and Victor Kress for their sage advice, friendship, assistance, and collaboration. I am grateful to Phil Goodell and Lisa Hardy for introducing me to practical mining geology, Peter Lichtner for helping me keep my signs straight, and my former graduate students Ken Raabe, Roy Hill, Mike O'Leary, Lauren Gee Carroll, William Azeredo, Denton Ebel, Daniel Harlov, Shuvo Ghosal, Irfan Yolcubal, Alexey Balabin, and Nathan Chutas for doing the hard work that makes all this possible. I thank my family, Odee, Filo, Milo, and O'Win, and their predecessors Olde, Fidelity, and Morgan, for always racing to my side. And, finally, I want to thank the Volcanology, Geochemistry, and Petrology section of AGU for this honor.

—Richard O. Sack, *OFM Research, Redmond, Wash.*



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How Much Carbon Dioxide Does Sunlight Release from Lakes?



J-O Eriksson, CC BY-NC-SA 2.0 (<http://bit.ly/ccbyncsa2-0>)

Water lilies along the shore of a lake in Sweden.

Humans are not the only ones who release carbon dioxide into the atmosphere. Inland waters, full of carbon-rich plant and soil material, are among the natural sources of the greenhouse gas. In recent years, scientists have found that the amount of carbon dioxide emanating from inland waters is substantial enough to warrant inclusion in the global carbon cycle—it is about a quarter of the amount pumped out yearly by fossil fuel burning.

Koehler *et al.* wanted to know how much of this carbon dioxide is the product of sunlight breaking down the carbon-rich material dissolved in the water. Their study is the first to look at this question on a large scale.

A data set of 1086 lakes across Sweden served as the basis for the study. Satellite data of cloud cover over the lakes provided insight into the amount of sunlight reaching the lakes. Model simulations

revealed the extent to which photons break down the matter dissolved in the water.

After modeling the amount of carbon dioxide emissions from lakes in Sweden—countrywide, about 150 kilotons of carbon per year—they extrapolated the result to come up with a number for lakes and reservoirs worldwide. They calculated that annual sunlight-induced carbon dioxide emissions were between 13 megatons of carbon under overcast sky and 35 megatons of carbon under clear sky.

That means that sunlight is responsible for up to 10% of the total carbon dioxide that comes from lakes and reservoirs worldwide. The study contributes to the growing body of evidence that lake-dwelling microbes contribute to the aquatic carbon cycle more substantially than previously thought, the authors say. (*Global Biogeochemical Cycles*, doi:10.1002/2014GB004850, 2014) —Shannon Palus, Freelance Writer

When Predicting Drought Risk, Do Not Overlook Temperature



California's Sandy Wool Lake and exposed lakebed on 31 August 2014.

As the Earth gets warmer, the risk of concurrent droughts and heat waves, such as those seen in California during 2014, could rise substantially. Precipitation is generally the only variable that scientists use to estimate how often droughts of a certain severity might occur. However, because this method ignores temperature, which can influence drought severity, it could inaccurately calculate the actual risk. *AghaKouchak et al.* analyzed how unique the 2014 California drought actually was, on the basis of not just precipitation or temperature alone but also those variables combined.

The authors obtained monthly precipitation and temperature data for California between 1896 and 2014 from the National Oceanic and Atmospheric Administration's U.S. Climate Division Database. With these data, the authors could model the California drought's return period—the number of years, on average, for a drought as severe as the 2014 drought to recur. The authors calculated this quantity, first using a statistical

technique based only on precipitation or temperature alone, then using another approach that combined both variables.

The 2014 California drought has a 24-year return period based on precipitation data alone and a 120-year return period based on temperature data alone, the researchers found. However, when the researchers considered the effects of precipitation and temperature together, the number rose to a 200-year event.

The findings suggest that modeling droughts' return periods based on precipitation alone could inaccurately convey their risks. The authors argue for further research into this multivariate approach, which they suggest could help policy makers and forecasters better prepare the public for future droughts. The method, the authors add, could be adapted for assessing the risks of different combinations of extremes. (*Geophysical Research Letters*, doi:10.1002/2014GL062308, 2014) —**Puneet Kollipara, Freelance Writer**

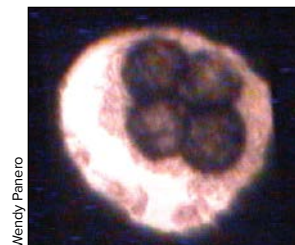
Dry Minerals in the Lower Mantle

Water may play an important role in the inner workings of our planet; by some estimates there could be as much water dissolved within the mantle as there is on the Earth's surface. The discovery of an ultradeep diamond last year hinted that the transition zone between the upper and lower mantle—some 500 kilometers deep—might be composed of 1% water. Furthermore, scientists have known for decades that the upper mantle contains some water, up to 500 parts per million.

In a laboratory, *Panero et al.* simulated the hot and harsh conditions of the Earth's interior to create and investigate perovskite, a common mineral of our planet's deep reaches. Curious about how much water might be locked up in the Earth's perovskite-rich lower mantle, the authors looked at the conditions in the region to determine if water could be dissolved within the mineral in the form of hydrogen monoxide.

In a laser-heated diamond anvil cell, at pressures similar to those found in the lower mantle, they synthesized perovskite. They peered into the mineral using X-ray diffraction, infrared spectroscopy, and electron microscopy to determine if and where water could bond within the rock. Additionally, the authors did theoretical calculations and thermodynamic modeling of the mineral's structure.

The authors found that perovskite in the lower mantle can hold only a very small amount of water, less than 40 parts per million at temperatures of over 1500°C. Colder regions might be able to hold 3 or 4 times that amount. According to the authors, if the lower mantle really is less suitable for water storage, the lack of the liquid may explain why the region is an order of magnitude more viscous than the adjacent upper mantle. (*Journal of Geophysical Research: Solid Earth*, doi:10.1002/2014JB011397, 2015) —**Shannon Palus, Freelance Writer**



Perovskite formed in the diamond anvil cell at high pressure by heating natural enstatite with an infrared laser. Each lobe of the "cloverleaf" is about 25 micrometers across.

Tipping Point for Nuisance Coastal Flooding May Come by 2050

Sea levels have been rising for thousands of years, but today they are swelling at an unprecedented rate. By the end of the century, modest projections predict that seas will rise at least another 0.5 meter—the same amount as over the last two millennia. The year 2100 is often perceived as a tipping point for when rising seas will set a “new normal” where frequent floods occur along coasts. However, according to the work of *Sweet and Park*, that tipping point may arrive even sooner.

As rising waters swallow up more and more land, flooding has become a significant problem in coastal communities. Nuisance flooding—floods between 0.3 and 0.6 meter—is 5 to 10 times more likely today than it was 50 years ago. The authors combined climate projections of global sea level rise, based on data from National Oceanic and Atmospheric Administration tidal stations with at least 60 years of records, with regional factors such as land subsidence and interannual variability in El Niño to show that the frequency of nuisance flooding events in the United States is rising much faster than average sea levels.

If the trend continues, the authors say that by 2050, many cities along the Mid-Atlantic, Gulf, and West coasts will experience 30 or more days with nuisance flooding a year. By the end of the century, nearly all the locations the study examined may face minor flood events on a daily basis. This “new normal” has



Future floods may not all be as devastating as this one in Long Island, New York, caused by Hurricane Sandy, but new projections suggest that small-scale events may become a daily issue for some coastal communities by the end of the century.

major implications for local governments and organizations responsible for building resilient coastal communities. The projected minor nuisance floods may not be catastrophic, but they can still be damaging and costly. (*Earth's Future*, doi:10.1002/2014EF000272, 2014) —**Kate Wheeling, Freelance Writer**

Water Beneath the Surface of Mars, Bound Up in Sulfates

We know that water lurks within Martian soil. But in what form?

According to measurements by Mars landers and rovers, Martian soil may store water in clays, unusual silica such as opal, and hydrous sulfates such as gypsum and even as ground ice. Hydrous sulfates, also found on Earth, tantalize researchers because they offer vital clues to the nature of soil habitability. Characteristics of this habitability include the acidity and concentration of brines that may occur, with possible relevance to seasonally observed flow features of soil within southern craters.

Data supporting the widespread presence of hydrous sulfates have been geographically limited: rovers and landers do not travel far. A new study widens the view. Taking advantage of years of data from the 2001 Mars Odyssey orbiter, *Karunatillake et al.* present maps of hydrogen and sulfur that may reveal

the importance of sulfates to storing water in the soil of southern Mars

The orbiter's gamma ray spectrometer senses the energy and number of photons—far more energetic than X-rays—coming from the Martian surface and thus the relative amounts of various periodic table elements needed to generate them. Analyzing peaks in the spectroscopic data that indicated the presence of sulfur and hydrogen, the authors estimate the molar ratio of water to sulfur to be between 2.4 and 4.0 for the majority of the planet's southern hemisphere, at depths approaching half a meter.

Meanwhile, the spatial association between hydrogen and sulfur at these regional scales suggests the possibility of sulfates binding water in bulk soil. Secondly, the ratios are consistent with those expected for many iron sulfates. Alternatively, mixtures of calcium and magnesium sulfates could also yield the signature.

Hydrous sulfates on Earth can form in brine pools as they desiccate. Iron sulfates in particular can also allow brines to exist at temperatures much lower than those of many chlorides. Thus, the widespread possibility of the hydrated minerals suggests that sometime in Mars's past, brines may have diffused through its bulk soil in processes that parallel the efflorescence that forms white fuzzy crystalline deposits in many a basement wall. Volcanic exhalations may have also contributed to the pervasiveness of hydrous soil sulfates.

Further, with the presence of such activity come the questions of a still-active water cycle, of fleeting pockets of brines across the Martian seasons, of a shallow reservoir of extractable water for human explorers, and maybe even of habitability for the hardest forms of life (*Geophysical Research Letters*, doi:10.1002/2014GL061136, 2014). —**Shannon Palus, Freelance Writer**

Conquering Uncertainties in Tropical Climate Forecasts

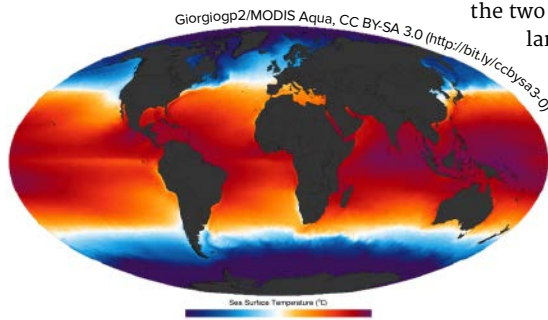
Observation and numerical climate model prediction do not always match when it comes to atmospheric temperature trends in Earth's tropics. Some skeptics have focused on the mismatch, and the question of a systematic problem in the models has been raised. Recently, *Flannaghan et al.* set out to find the source of the problem.

The researchers studied the impact of two commonly used, but subtly different, data sets of sea surface temperature on multiple climate models—the HadISST1 and the Hurrell data sets. Both are based on measurements from ships and buoys as part of the Comprehensive Ocean–Atmosphere Data Set project, but after 1981 the data sets diverge following the onset of including measurements from satellite instruments using different algorithms. The team plugged both data sets into the Geophysical Fluid Dynamics Laboratory's High Resolution Atmospheric Model (HiRAM) and the National Center for Atmo-

spheric Research's Community Earth System Model (CESM) and found that sea surface temperature trends are the biggest driver of uncertainty—more important even than which model was used.

The group discovered that several years around 1982/1983 were particularly problematic in the data, but the main problem is that

the two sea surface temperature data sets show the largest trend differences right in the regions where they matter most for the atmosphere, namely, in the regions that form tropical convective storms. Trend differences there are about a factor of 3 larger than for the tropical average, leading to a 50% difference in the models' atmospheric temperature trends for the period 1984–2008. The team concludes that unraveling the discrepancies will be crucial to understanding recent tropical climate trends. (*Journal of Geophysical Research: Atmospheres*, doi:10.1002/2014JD022365, 2014) —**Eric Betz, Freelance Writer**



Errors in sea surface temperature data may be to blame for the disconnect between prediction and observation in atmospheric temperature trends in the tropics.

Do All These Weather Satellites Really Improve Forecasts?

Modern weather forecasting relies on measurements of current conditions to project what will happen in the future. The accuracy of these predictions is only as precise as observational data. Currently, about 90% of that information comes from satellites.

According to *Singh et al.*, spacecraft data have been revolutionary for weather prediction in the Southern Hemisphere, where ground measurements are sparse. However, as the suite of orbiting instruments grows, it is unclear if all these new observations result in better predictions. The authors decided to test the impact of a broad array of observing systems on weather forecasting models over India. The team carried out 21 experiments through July—the summer monsoon season—in 2012.

Their analysis shows that wind observations have a large impact on the accuracy of a forecast, especially in the short term. Removing wind observations reduced the accuracy of a forecast's rainfall estimates by as much as 30%. Unfortunately, current space-based weather instruments are heavily biased in favor of measuring atmospheric mass instead of wind, the authors say. That will change, the authors say, when the European Space Agency's Atmospheric Dynamics Mission (ADM–Aeolus)—the first spacecraft to acquire global wind profiles—launches in 2015.

The instrument that played the largest role in reducing forecasting errors, including rainfall predictions, is one that weather agencies



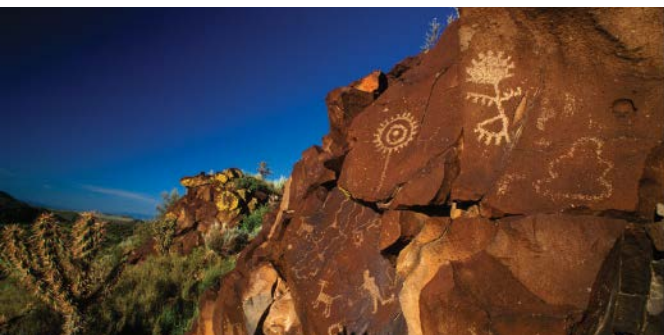
Artist's concept of the U.S. National Oceanic and Atmospheric Administration's Geostationary Operational Environmental Satellite (GOES-R) weather satellite. GOES-R is scheduled to launch in 2016.

have used regularly for close to a century: radiosondes. The expendable instrument packages, mounted to small weather balloons, relay pressure profiles, temperature, and relative humidity. The instruments also measure wind speed and direction. (*Journal of Geophysical Research: Atmospheres*, doi:10.1002/2014JD021890, 2014) —**Eric Betz, Freelance Writer**

Which Chapman Will You Be Attending in 2015?



Evolution of the Asian Monsoon and its Impact on Landscape, Environment and Society: Using the Past as the Key to the Future
Hong Kong SAR, China
14–18 June



The Width of the Tropics: Climate Variations and Their Impacts
Santa Fe, New Mexico, USA
27–31 July



Magnetospheric Dynamics
Fairbanks, Alaska, USA
27 September–2 October



The MADE Challenge for Groundwater Transport in Highly Heterogeneous Aquifers: Insights from 30 Years of Modeling and Characterization at the Field Scale and Promising Future Directions
Valencia, Spain
5–8 October

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Geochemistry

The Geosciences Research and Applications Group at Sandia National Laboratories (Albuquerque, New Mexico) has openings for multiple postdoctoral researchers. Depending on the applicant's background, the research could involve 1) computational fracture mechanics, 2) constitutive hydro-mechanical-chemical models, 3) integration of multiscale-multiphysics models, 4) classical molecular dynamics, 5) quantum methods, 6) experimental geomechanics, and/or 8) experimental geochemistry. To apply visit www.sandia.gov/careers and access the full posting using ID# 649428.

Ocean Dynamics and Prediction Research Naval Research Laboratory



The Naval Research Laboratory is seeking postdoctoral and senior researchers to push forward the frontiers of ocean forecasting. Problems that must be addressed cover a wide scope of physics including surface waves, thermohaline circulation, ice, nearshore circulation, and ocean/atmosphere coupling from global to nearshore scales. This challenging work includes processing and analysis of satellite and in water observations, construction of numerical model systems and assimilation for predicting the ocean environment. This work is long term, with the goal to provide new technology for systems moving to operational forecast centers.

This is an excellent opportunity to work with some of the best modelers and data analysts in the ocean community. The Naval Research Laboratory has access to the major supercomputer sites as well as excellent local computer resources. The laboratory is collocated with the Naval Oceanographic Office, which is the largest national operational forecast center for oceanography.

For a quick overview of some of the research projects within the NRL Oceanography Division at Stennis Space Center, visit the web site:

<http://www.7320.nrlssc.navy.mil/projects.php>

Applicants must be a US citizen or permanent resident at time of application. Applications will be accepted until positions are filled. Please mail or e-mail a resume and description of research interests, or phone:

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Ocean Sciences

PHYSICAL OCEANOGRAPHER/ MARINE GEOPHYSICIST Experimental Ocean Electrodynamics

The University of Washington Applied Physics Laboratory (APL) seeks a sea-going experimental physical oceanographer or marine geophysicist to lead a program in ocean electrodynamics. The successful candidate will be expected to develop an observational/experimental ocean or coastal research program with an emphasis on innovative sensor development and use. Present activities include theory, modeling, instrumentation, and field programs spanning basic research to applied and classified efforts. Historically, this program has implemented motionally induced voltage sensors on many platforms (e.g., ships, profilers, gliders, floats, drifters, landers and submarine cables) to study oceanic flows and turbulence. Newer topics include adding turbulence sensors to EM-APEX floats, EM remote salinity profiling in marine estuaries, observing the global electric circuit and installing EM sensors on NSF's OOI submarine cable. Several measurement systems are available for immediate use for both ocean velocity and magnetotelluric studies.

Candidates should have a demonstrated record of research and development in the ocean. A senior candidate should have existing funded projects. A junior candidate should have strong potential to fund independent projects. APL will provide bridge salary and support for engineering services. Candidates who can obtain a US security clearance are preferred. The Seattle area has an active oceanographic community with a variety of strong institutions and active colleagues.

For more information and to apply for this position, visit: <http://www.apl.washington.edu/jobs/jobs.php>

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A Ph.D. degree is required; additionally, Habilitation (post-doctoral lecturing qualification), an exemplary record of research achievement as an assistant / an associate / a junior professor or university researcher and/or an outstanding career outside academia are highly desirable. Ability in and commitment to teaching are essential. German is not necessary to begin but will be expected as a teaching language within the first 5 years. Relevant professional on-the-job experience in Engineering Geology is desired. The application should include supporting documents regarding success in teaching. Please send a cover letter stating research aims and a CV to: An den Dekan der Fakultät für Georesourcen und Materialtechnik der RWTH Aachen, Univ.-Prof. Dr.-Ing. Wolfgang Beck, 52056 Aachen, Germany. The deadline for applications is 30-June-2015.

This position is also available as part-time employment per request. RWTH Aachen University is certified as a family-friendly university and offers a dual career program for partner hiring. We particularly welcome and encourage applications from women, disabled people and ethnic minority groups, recognizing they are underrepresented across RWTH Aachen University. The principles of fair and open competition apply and appointments will be made on merit.

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Postcards from the Field

Hello, all,

Greetings from Hutton's Unconformity, on the island of Arran, Scotland. It's where James Hutton first saw evidence for huge gaps in time in the rock record, leading him to declare that there was "no vestige of a beginning, no prospect of an end." Today we take students there as part of their first geology field trip. They find Precambrian Dalradian rocks sitting unconformably beneath late Devonian sediments of the Kinnesswood formation.

Wish you were here!
Simon

View more postcards at
<http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field>.



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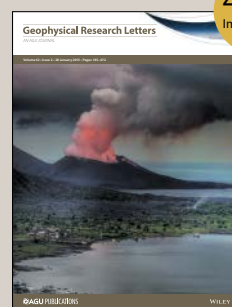
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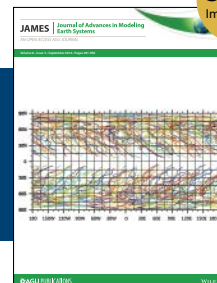
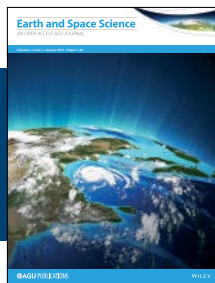
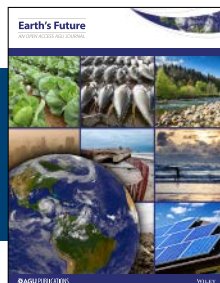
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